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Irrigation, as shown in the cover picture, is a common practice in Latin American commercial crop culture. An article on the agriculture of Latin America is published in this issue.

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Volume 2
Readers are asked to note that this will be the last issue of Span, *Volume 2. The next issue, due to be published at the beginning of 1960 will be Volume 3. No. 1.*

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PESTICIDES

The modern pesticides industry was born in the years immediately following World War II. From its earliest days it has been a lusty infant which has grown in a phenomenal manner. During its 15 years of life, many doubts have been expressed about the child's prospects. Now, as it approaches adolescence, it is possible to take stock of its course thus far and to draw attention to some pointers for its future.

Various estimates have been made of the breakdown of the market for agricultural chemicals between the various groups of products which comprise it. One recently published estimate of the US market is as follows:

Insecticides	50-59%
Fungicides	18-25%
Herbicides	13-21%
Fumigants	4-10%

For the world as a whole, fungicides probably account for a rather larger proportion of the total market. The value of the world market, excluding the Russian share, has grown from £40 million in 1944 to £125-140 million at manufacturing level at the present time. About half of the total consumption of pesticides in the world is accounted for by the United States.

In recent months, several leaders of the industry have drawn attention to the fact that a high level of agricultural chemical research effort, entailing exceptionally high expenditure, can only be supported if satisfactory profits are derived from successful new products once they become established. This need is well illustrated by the fact that some large firms have been screening 3,000-4,000 compounds every year as potential pesticides without discovering a successful compound over long periods of time.

Patent Coverage

Experience has shown that it is not possible to earn satisfactory profits on new pesticides unless the inventor is able to enjoy a degree of exclusivity with his product. In the pesticides field, exclusivity generally implies patent protection, since the other traditional forms of protection in the chemical industry, namely manufacturing 'know-how' and favourable raw materials and geographical situation, do not generally apply. The corollary of this is that, unless there is a possibility of obtaining a satisfactory patent position, few manufacturers are prepared to probe deeply into any particular field of pesticide chemistry, however promising it may be. This situation has been aggravated in recent years by the need to carry out the expensive and laborious work of obtaining official approval for the use of new products which others will be free to exploit unless the inventor has some degree of protection.

This trend is well illustrated in the case of some of the older pesticides (for example, tetramethylthiuramdisulphide [TMTD]) which are manufactured by a large number of chemical firms without any one of them being willing to undertake development work to extend the existing fields of use of these compounds.

Even where an inventor is able to obtain patent protection for his product, and starts to develop its use energetically, his period of protection in the majority of countries is something of the order of 15-20 years. The philosophy underlying the grant of patent rights is that this is a reasonable period of time for an inventor to enjoy his monopoly before his invention passes to the public domain.

In the case of many inventions, for example in the field of light engineering, it could be argued that this is the case. In the field of pesticides, however, because of the seasonal nature of field testing and because of the need to carry out tests under a variety of conditions, it may well be seven years from the date of the discovery of the compound before it arrives on the market on a fully commercial scale. It may then be another five years before the new product has penetrated the market to a significant degree, leaving only a few years in which the inventor can obtain a return on his research and development investment.

THE INDUSTRY AFTER 15 YEARS

by **A. C. Lowe,** *Shell International Chemical Company*

In some cases, particularly where a manufacturer is introducing a revolutionary compound or one involving a completely new technique, it may even take longer to make a penetration of the market, with the result that the product is getting into its stride only when the patents are beginning to expire. It can be seen, therefore, that many large firms now consider that it is just as important to have an organisation which can quickly develop the market for a new compound as it is to be able to discover new compounds from its own research.

Research Targets

An analysis of patent activity over the past few years suggests that commercial firms as a whole have been devoting their research efforts primarily to the discovery of new insecticides, secondly to fungicides and lastly to weedkillers.

Dealing with insecticides first, leading research workers have expressed the opinion that it will become increasingly difficult to find successful new compounds in the traditional fields. Disregarding for the moment the insect resistance problem, there is already available a wide range of insecticides which are extremely efficient from the point of view of both performance and cost.

As far as fungicides are concerned, the older inorganic fungicides, with 100 years of use behind them in some cases, have proved difficult to dislodge, although the thiocarbamates and Captan continue to make headway in this field.

In the weedkiller field, the chloro-phenoxy group of selective hormone weedkillers are extremely efficient within the important but technically narrow field in which they are used. Effective weedkillers do not exist at the present time for the solution of problems such as, for example, the control of grasses in graminaceous crops, weeds of all sorts in broad-leaf crops, and grasses in perennial crops. Since weedkillers are essentially substitutes for labour (in contrast to fungicides and insecticides) and since labour is likely to become a scarcer resource in the future, particularly in highly developed countries, it is possible that greater emphasis will be placed on the discovery of new herbicides, and possibly of growth-promoting substances which stimulate crop growth selectively.

Of all the problems which confront the industry, the control of nematodes probably represents the most important frontier in pest control at the present time and it seems likely, therefore, that greater effort will be directed to discovering more effective nematocides in coming years. In this particular field, however, the most pressing need is for education on the incidence of plant parasitic nematodes and on the extent to which they reduce crop yields. The shortage of trained nematologists and other research facilities in which to study nematodes is undoubtedly hampering progress.

Old Products

Attention has often been drawn to the way in which agricultural pesticides become obsolete rather quickly. Farmers and advisory workers frequently complain about the bewildering variety of new materials constantly becoming available for their use. Dealers in the USA state that 10 per cent of the proprietary pesticides on their shelves in any one year will not be there the following year. Rather surprisingly, therefore, total production of DDT and 2,4-D, which could be regarded as the 'founder products' of the modern industry, continues to rise every year even though the proportion of the market held by them continues to decline.

New Products

In many ways 1958 was a 'vintage' year for new pesticides. Amongst the large crop of new compounds introduced to the market in that year, the following are perhaps the most interesting:—

Cyprex. Although the fungicidal activities of guanidine

and its derivatives have been known for some time, American Cyanamid have developed the first commercial fungicide of this class (N-dodecyl guanidine acetate) under the trade name Cyprex. Reports indicate that although it is phytotoxic on some varieties, it is highly effective in suppressing, and even eradicating apple scab, *Venturia inaequalis*.

Delnav. Delnav is the trade name for Hercules Powder Company's organo-phosphorus acaricide 2:3-paradioxane-dithiol-S,S-bis-(O,O-diethyl dithiophosphate). It has shown promise not only for the control of mites on cotton and fruit crops but also in veterinary applications such as cattle tick control. The low mammalian toxicity of the compound makes this latter use possible.

Phosdrin.[1] Although it was first synthesised and tested some years ago, Shell's Phosdrin (O,O-dimethyl-O-1-methyl-2-carbomethoxy-vinyl phosphate) has become available commercially only comparatively recently. Some years ago its short-lived systemic action and high acute oral toxicity would have severely limited its prospects. However, the current emphasis on the need to be able to control insect infestations shortly before harvest without giving rise to toxic residues on the crop, coupled with improved knowledge and experience in safe handling of organo-phosphorus compounds, have opened the door for the development of this compound, which appears to have a bright future.

Sevin. Although it is not the first carbamate insecticide on the market, Sevin (N-methyl-l-naphthyl carbamate) represents an interesting technical break-through since it appears to be the first effective insecticide which is not a member of either the chlorinated hydrocarbon or the organo-phosphorus group of insecticides. Problems of formulation, phytotoxicity and range of insects controlled by Sevin may still have to be resolved. The manufacturers, Union Carbide, have announced that they are proceeding to large scale production of this compound.

Trolene. The idea of administering systemic insecticides orally to animals to rid them of insect and other arthropod parasites has always been an ideal in the minds of entomologists and veterinary surgeons. Dow Chemical Company have developed the first commercial scale compound of this sort, an organo-phosphorus compound formerly identified by the code, ET-57 but now given the trade name Trolene. The compound, which is chemically O,O-dimethyl O-2,4,5-trichlorophenyl thiophosphate, has been approved by the US authorities for the control of cattle grub.

Insect Resistance

In the agricultural sector, fresh reports of insect resistance to insecticides, particularly to chlorinated hydrocarbon insecticides, are no longer news. As might be expected, the incidence of resistance has been most pronounced on such crops as cotton, which may receive 15 or 20 applications of insecticide a season, or in circumstances where the insect parasitises a single crop or animal with no alternative host.

In these latter cases a very high proportion of the total population of insects may receive treatment with insecticides resulting in the rapid elimination of non-resistant members and the development of a very pure resistant strain.

The sheep blowfly provides an interesting illustration of this tendency. In England, the sheep blowfly has a number of alternative hosts apart from the sheep. Despite widespread use of chlorinated hydrocarbon insecticides in sheep dips, there have been no reports of blowfly resistance in England. By contrast, in Australia, where the blowfly appears to have become resistant to chlorinated hydrocarbon insecticides in some areas, the sheep blowfly has no known host apart from the sheep.

Seven important species of malaria-transmitting mosquitoes have become resistant to the chlorinated hydrocarbon compounds during the past eighteen months or so. The implications of insect resistance in the public health field appear to be more serious than is the case with crop protection since the alternatives to the chlorinated hydrocarbon insecticides, i.e., the current organo-phosphorus compounds, are not generally suitable for anti-malaria programmes. The World Health Organisation views the situation with concern; certainly a resurgence of malaria in populations which have lost their natural immunity as a result of previous control measures could have extremely serious consequences in some parts of the world.

Growth of the modern pesticides industry has by any standards been dramatic. As a result of the use of pesticides, crops are now grown where they could never have been grown before, resulting in the transformation of the economies of large regions of the world in some cases. Crippling diseases which have afflicted millions of people for centuries have been brought under control or even eliminated in a matter of 15 years.

For the future, two things are certain. First, the use of pesticides will continue to increase rapidly as the pressure of world population on limited food resources becomes more critical. Secondly, the face of the pesticides industry will change markedly in the next 15 years. In common with all agricultural activities, the use of pesticides results in a disturbance of the existing relationships between plants, insects and animals, setting in motion waves of reaction. This will result in a constantly changing panorama of new problems, new products and new uses for existing products in the pesticides industry.

PROFESSOR M. G. MES

We report with regret that Professor Margaretha G. Mes, author of the article, Symbiotic Nitrogen Assimilation in Legumes, published in the last issue of *Span*, died in July, after we had gone to press. Professor Mes was Professor of Botany and Head of the Plant Physiology Research Institute at the University of Pretoria, Transvaal.

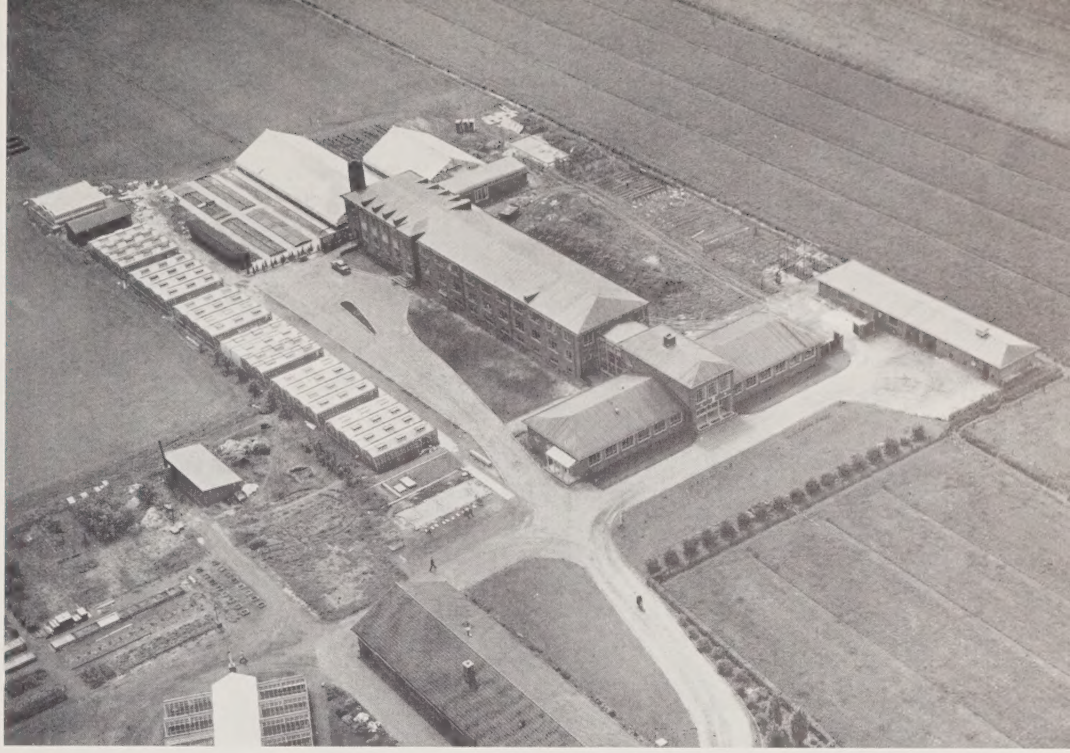
[1]Phosdrin is a Shell trade mark.

AGRICULTURAL RESEARCH STATIONS—2

Wageningen Agricultural Centre

and the Institute of Phytopathological Research

by **J. G. ten Houten**
Director of the Institute.



Wageningen's Institute of Phytopathological Research (I.P.O.).
Photo: K.L.M. Aerocarto

The name Wageningen is widely associated with agricultural research and education in the Netherlands: exactly what constitutes the Centre of Agricultural Science at Wageningen is probably less generally known. In fact, the Centre comprises a large number of separate research units—most of them under the aegis of the National Council for Agricultural Research—and the State Agricultural University.

In the following article, after briefly outlining the history of the Centre, the author describes the work of one of its research institutes, the Institute of Phytopathological Research, of which he has been Director since its foundation in 1949.

A list of the agricultural research institutes at Wageningen, with an indication of the scope of their work, is given in an appendix to the article. As a guide to the relative sizes of the various institutes, the numbers of graduates (Ph.D. and M.Sc.) working in each are shown.

In spite of the present rapid growth of industry in the Netherlands, agricultural and horticultural production, including cattle, dairy products, eggs and poultry, is still of great economic importance to the country. Since 1938 total agricultural production has increased by 30 per cent, while the monetary value went up from 1,114 million guilders in 1938 to 5,657 million guilders in 1956. In the same year the export of all Netherlands agricultural products together amounted to 3,187 million guilders. This represents about one-third of Holland's total export.

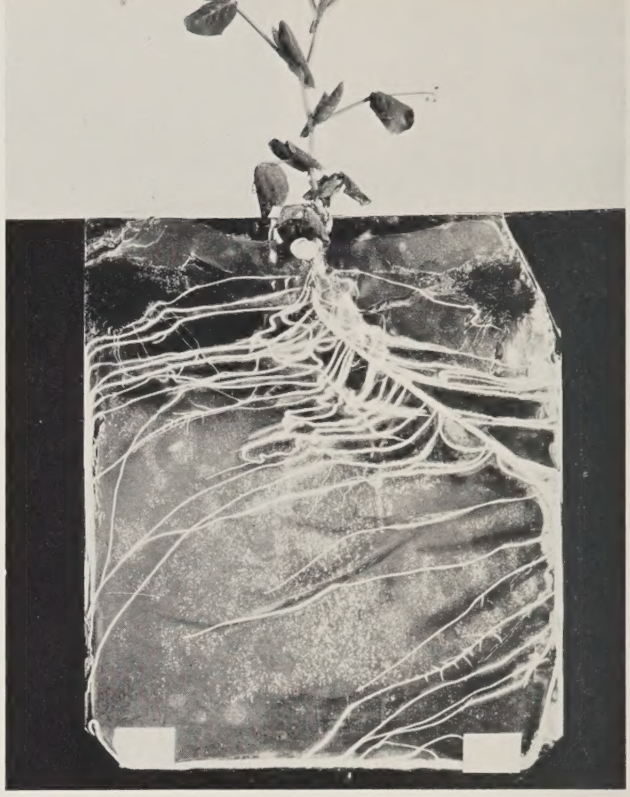
This increase in agricultural production is to a large extent due to improved farming, resulting in higher yields and better quality products. Both ultimately originate from careful scientific research, a high standard of agricultural and horticultural education and an efficient advisory service. Conservative though the Dutch farmer may be, he is very interested in improvements which will bring him increased profit for his labour. The average Dutch farmer has great confidence in the results of research, and is quick to adopt improved methods once they have been shown to be of advantage.

The Dutch Government has fully realised the necessity for agricultural research in achieving greater production and since the last war the programme for research has been greatly expanded. At present, over 25 million guilders are spent on agricultural research annually, excluding the expenditure of the State Agricultural University, where, besides the training of students, much fundamental research is carried out.

Of this total, about 17.5 million guilders go to the research institutes at and around Wageningen. The great majority of these institutes are foundations falling under the supervision of the National Council for Agricultural Research; each has its own board on which representatives of farmers' associations, government officials and university professors are appointed by the Minister of Agriculture.

At Wageningen there is an International Agricultural Centre which arranges for students, including post-graduates, from abroad, to work at a university laboratory or at one of the institutes. It also issues an annual detailed guide to all the laboratories at Wageningen. Each summer the International Centre organises one or more training courses, usually in co-operation with the Food and

Plastic bags containing a sterile nutrient solution in agar-foam, specially adapted for research with nematodes and fungi.



This glass mosaic at the IPO symbolises the threat of rust to healthy wheat.

Agricultural Organisation of the United Nations; subjects covered so far include methods of agricultural extension, land development, and home economics extension. The first international course on crop protection will be held during August, 1960.

Wageningen's Origin

The first agricultural experimental station in the Netherlands was founded at Wageningen in 1877, one year after the establishment of the school of agriculture, to which it was attached. About the end of the nineteenth century the government seed testing station and the Plant Protection Service were separated from the main agricultural experimental station. In the meantime the school of agriculture had developed into the State College for Agriculture, Horticulture and Forestry, to which were attached certain institutes, such as the Institute for Phytopathology and the Institute for Breeding Agricultural Crops.

In 1917 the government decided to promote the State College to be the sole State Agricultural University in the Netherlands. Afterwards it was gradually felt that research on the many practical problems facing the farmer took too much of the time of the university staff, and special institutes for applied agricultural research were established, partly by farmers' organisations, but mainly by the government. Most of the government institutes are subsidised to some extent by farmers or commercial organisations.

Extensive development has taken place since the last war, and in 1958 the total number of scientists, including university professors and lecturers, was 217 in the university laboratories and 362 in the other research institutes. The total staff of the University and the Wageningen institutes together number about 2,500. These institutes are listed as an appendix to this article.

THE INSTITUTE OF PHYTOPATHOLOGICAL RESEARCH (IPO)

The Institute of Phytopathological Research was established 10 years ago, at a time when the need was felt for more concentrated research, particularly in view of the fact that several pests and diseases were not disappearing as they should after treatment with pesticides. Evidently there were factors favouring the development of the organisms concerned and only careful study would be likely to reveal weak spots in their life cycles. The life cycles of many parasitic fungi, bacteria, nematodes, mites and insects therefore had to be investigated. The effect of environmental conditions on the spread and development of these organisms had also to be taken into account. It was to enable such studies to be carried out that the IPO was established. During the war some individual agricultural research workers had been appointed; they mostly found hospitality in university laboratories, but eventually they were taking up too much space at the expense of the students for whom the laboratories had been built. By setting up the IPO as a separate organisation the situation was improved.

The total staff of the IPO numbers 106. There are 34 scientists (half of them biologists, and half horticulturalists and agriculturalists with a Wageningen degree). Most of the research workers have specialised in plant pathology, including virology, applied entomology, or nematology, but some are plant physiologists or biochemists. Although most of these research workers are stationed at Wageningen, for the study of pests and diseases of certain

horticultural crops it was found desirable to send a plant pathologist or entomologist to the major growing centre for each crop; these specialists work at experimental stations for fruit growing, at Goes; for vegetables, at Alkmaar; for fruit and vegetables under glass, at Naaldwijk; and for flowers under glass, at Aalsmeer.

The subjects studied at the IPO are divided among the following departments and sections: mycology and bacteriology; virology; entomology; nematology; plant disease resistance; agricultural aviation section; and air pollution research section.

Mycology and Bacteriology

In the mycology-bacteriology department many diseases are studied with the aim of discovering a method of controlling the organisms under field conditions. Thus it has been possible to establish a correlation between meteorological conditions and the outbreak of onion downy mildew, *Peronospora destructor*. Neck rot of onions caused by another fungus, *Botrytis allii*, can be markedly reduced by an artificial drying process (as, in addition, the colour of the onions is greatly improved by drying, many onion growers have built their own ventilated and temperature conditioned stores).

Several potato diseases like *Rhizoctonia*, scab, *Actinomyces scabies*, and dry rot, *Fusarium caeruleum*, are under investigation, in the laboratory, the glasshouse and on experimental fields all over the country. By using climate chambers with adjustable temperature and humidity it has been possible to find the best conditions for potato storage without serious trouble from dry rot or potato skin diseases such as silver scurf, *Spondylocladium atrovirens*. Although *Rhizoctonia* potato tuber disease may be considerably reduced by chemical tuber treatment and/or soil disinfection, complete control cannot be achieved as on certain soil types such treatment is not effective. A study is now to be made of the possibilities of stimulating antagonistic fungi, such as *Trichoderma lignorum*, in the soil.

An interesting hygienic measure has been used for the control of raspberry cane diseases, in which the so-called May shoots are cut away to prevent the gall midge, *Thomasiniana theobaldi*, from laying its eggs. If the larvae of this midge damage the cortex of the cane, weak parasitic fungi (e.g., *Botrytis cinerea* and *Didymella applanata*) can develop, destroying the entire cane. Our bacteriologist is trying to isolate bacteriophages from various sources with the object of discovering specific phages which will allow a rapid determination of phytopathogenic bacteria. Fungus or bacterial diseases of flax, poppies, carnations, apples, cherries and gherkins are also under investigation.

Virology

In the virology department much attention is paid to the potato virus diseases, leaf roll and viruses X, Y and S. In the first place, the speed of transportation of the virus from the leaf to the tuber has been investigated. During this work 'old age resistance' of the leaf was discovered. In order to develop a quick method of diagnosing viruses in the leaves before symptoms can be seen, a biochemical analysis was made of healthy and diseased plants. With the aim of detecting viruses in tubers a staining method, already in use on a large scale for seed potatoes, is being improved.

A serious disease of cabbage, the so-called 'stip' (specks) appeared to be caused by a cauliflower mosaic virus. It could be transmitted only by the cabbage aphid, *Brevicoryne brassicae*. In 1949 the disease caused a loss of over one million guilders on one auction alone. Since the discovery of the cause of this disease and the aphid vector, control measures have been taken every spring, and all seed cabbage plants in the area are now sprayed with systemic insecticides by contract sprayers. As a result, the disease is no longer of importance.

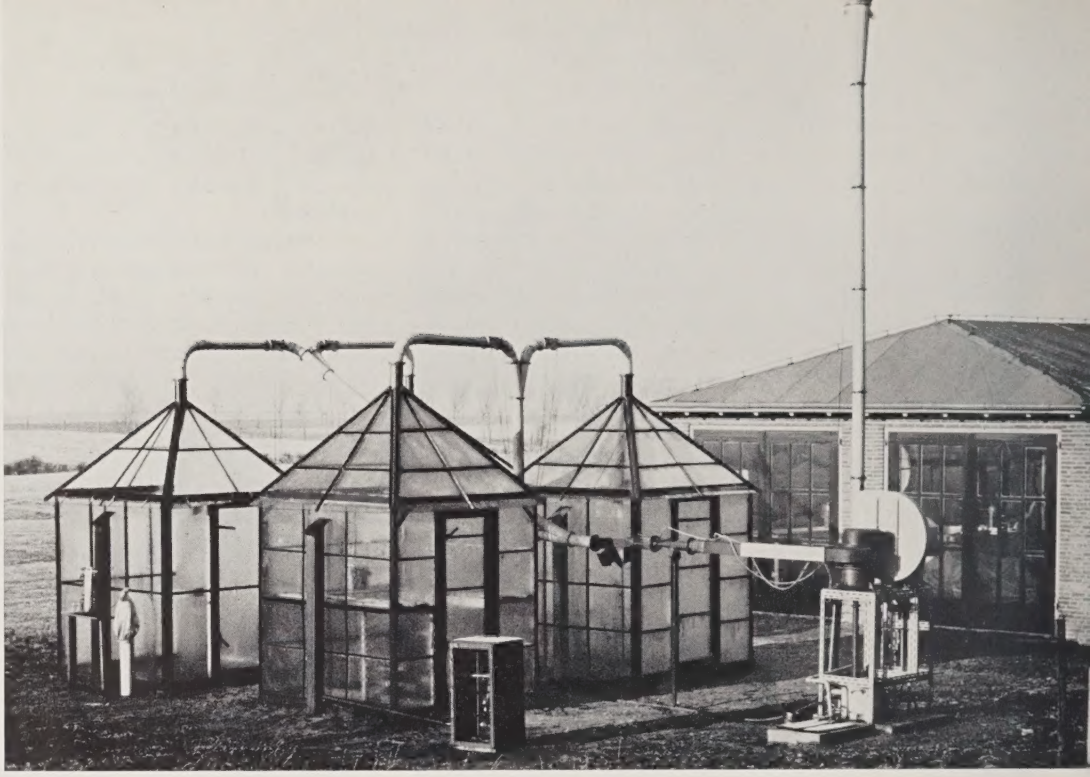
Another successful control of a virus disease, the rubus-stunt of raspberries, could also be obtained by killing the insect vector, in this case the leafhopper, *Macropsis fuscula*, which was found as vector after endless negative experiments with aphids and some 20 different leafhopper species. The virus transmitted by *Macropsis* causes a peculiar stunt and 'witches' broom' of raspberries. It started to become very serious in 1946, in Holland's main raspberry district (near a large canning industry). The growers connected the disease with the use of DDT as it had caused no trouble before the advent of this insecticide. What had happened was that when DDT became available the raspberry growers who formerly used tar-oil winter washes against 'red-worm', *Lampronia rubiella*, switched over to DDT in summer. The tar-oil winter wash killed not only 'red-worm', but also the eggs laid by *Macropsis* just beneath the cuticle of the bark. *Macropsis* is not very sensitive to DDT and was able to build up very rapidly; a small virus source being present, this caused disaster in the raspberry area as the disease is capable of rendering more than 80 per cent of the fields non productive. Growers have reverted to tar-oil winter wash and by some other additional control measures this virus disease is now fully under control.

By using a combination of a heat treatment and meristem culture (taking shoot tips of only 100μ) we succeeded in curing systemic virus diseases of carnation clones. By more elaborate methods of meristem culture in combination with chemical treatments, X-virus diseased early potatoes could also be cured. This method seems of particular importance for many vegetatively propagated plants which never become healthy again under normal conditions once they have been infected with the virus.

Other investigations are carried out on virus diseases of beans, peas and other pulse crops, cherries and gherkins. By breeding mosaic disease resistant gherkins (pickling cucumber) about one million guilders were saved in 1957 in one area, where all other varieties gave an almost total failure. Interesting work is going on in the field of soil-borne virus diseases, a group which appears to be much more common than was thought some years ago.

Entomology

Some of the work of the entomology department has been mentioned already. The virus vector work is also of great



Fumigation houses with adjustable temperature and humidity, in use for measuring the influence of such air pollutants as HF and SO_2 on crop plants.

importance in connection with strawberries: by killing the specific strawberry aphid, *Pentatrichopus fragaefolii*, at the right time, it has been possible to control the spread of strawberry viruses. Technically, most orchard insects are now under control, a state that has been obtained by combining careful phenological[1] investigations with the screening of all available insecticides. The entomology department is now concerned with controlling orchard insects and mites by combined chemical and biological methods. Where possible, specific insecticides and acaricides will be used, thus enabling parasites and predators of the noxious insects to help in keeping down the population of the pest. This is an urgent problem; the red spider mite, *Metatetranychus ulmi*, for example, is becoming increasingly resistant to insecticides, acaricides and ovo-larvicides.

The successful control of many insect pests of beans and peas, by correlating the growing stage of the crop, the development of the insect and the control measures, has led to an annual saving of several million guilders. In addition, the control of vegetable insects such as the carrot fly, *Psila rosae*, is now possible by insecticidal seed treatments. Insects which attack brussels sprouts, flax, clover, chicory and willow-trees are still under investigation.

Nematology

The nematology department is carrying out population studies using a method by which over 90 per cent of the eelworms present in a soil sample can be collected. The influence of crop rotation on eelworm populations is being investigated with particular regard to *Ditylenchus dipsaci*, bulb or stem eelworm, and *Hopolaimus uniformis*, a root eelworm. A very interesting method has been developed by which it is possible to grow plants in a plastic bag on agar foam with a nutrient solution; this enables the investigator to observe microscopically the movements and biology of eelworms. The method has also been employed for observations of combined root attacks by eelworms and parasitic fungi: the eelworm *Hopolaimus* alone and the fungus *Fusarium sp.* alone caused hardly any damage to peas, but a combination of the two almost killed the entire root system. The method originated from a search for a practical way of testing possible systemic nematocides against the potato root eelworm, *Heterodera rostochiensis*.

Plant Disease Resistance

The department for plant disease resistance was established in order to help breeding institutes and private breeders with infection material and reliable testing methods. Careful studies are made of the physiological races of parasitic fungi such as yellow rust of wheat, *Puccinia glumarum*, and the cause of bean anthracnose, *Colletotrichum lindemuthianum*, and clubroot of crucifers, *Plasmodiophora brassicae*. After breeders had been provided with a combination of all important races of *Colletotrichum* they were able to breed anthracnose-resistant bean varieties which are now coming into use. This department is also responsible for the testing of all new varieties of wheat, barley, flax, beans and peas for susceptibility to the major diseases.

Agricultural Aviation

The section for agricultural aviation gives help and advice to agricultural aviation companies. It pioneered aerial spraying with pesticides and made the technique sufficiently attractive for six companies to start as aerial spraying

[1]Phenology is the study of the influence of environment on the appearance of (noxious) organisms.

contractors. By 1951 we had established that control of potato late blight with copper fungicides was as good when the fungicides were sprayed from the air as when they were applied by high or low volume ground sprayers.

Work on distribution of spray liquid and measurement of droplet sizes is still going on, as well as the colorimetric estimation of spray deposits and the redistribution of copper and carbamates after rain or dew. Trials on the control of insect pests, fungus diseases and weeds are being carried out in conjunction with commercial firms.

Air Pollution

The air pollution section is fairly new. Its function is to investigate the influence of poisonous industrial gases, such as sulphur dioxide and fluorine, on crop plants. For this work special glasshouses in which temperature, humidity and air circulation can be controlled have been built; these enable a constant flow of air containing a known concentration of the poisonous gas to be applied to various plants. Most plants are extraordinarily sensitive to fluorine; even a concentration of 20 parts hydrogen fluoride per milliard parts of air causes damage to certain *Gladiolus* varieties.

By laying out several small plots with HF- and SO_2-susceptible plants in an air polluted area it is often possible to discover which industry is causing the trouble, although if the industrial area is large, with a variety of industries, it will be difficult to locate the source of pollution. In addition to diagnosis by symptoms, which in many cases is not possible in the field, chemical analysis in the laboratory is necessary to identify the cause of the damage to plants and thousands of leaf samples are analysed for SO_2 or HF during the winter. The aim of all this work, the reduction of air pollution, can, of course, only be achieved with the co-operation of industry; fortunately, in the Netherlands, industry is co-operative.

Appendix. Agricultural Research Institutes at Wageningen*

(Note: The numbers of scientists at institutes, shown below, refer to those with a doctorate or M.Sc. degree only.)

I. **State Agricultural University.** *Laboratories*, 25; *professors*, 45; *lecturers*, 19; *scientists*, 153; partly for instruction of students, but chiefly engaged in research. Generally speaking the more fundamental work is carried out at the university laboratories.

II. *Foundations falling under the supervision of the National Council for Agricultural Research.*

1. **Soil survey institute (Stiboka).** *Scientists*, 35.
2. **Institute for land and water management research (I.C.W.).** *Scientists*, 24. Research on water management (hydrology, irrigation, drainage, water relationships of plant and soil), soil improvement, land division and economics of land consolidation projects.
3. **International institute for land reclamation and improvement (I.L.L.C.).** *Scientists*, 6. Collects and disseminates world-wide information on land reclamation and land improvement, and applied scientific research on this subject.
4. **Institute of biological and chemical research on field crops and herbage (I.B.S.).** *Scientists*, 27. Research on growth, development and preservation of field crops and pasture plants; weed control; general physiology of field crops; chemistry of field crops.
5. **Research and advisory institute for field crop and grassland husbandry (P.A.W.).** *Scientists*, 40. Central Advisory Service for all matters relating to field crops and grassland; carrying out of supplementary research.
6. **Forest research station "De Dorschkamp".** *Scientists*, 6.
7. **Foundation for agricultural plant breeding (S.V.P.).** *Scientists*, 14.
8. **Institute of horticultural plant breeding (I.V.T.).** *Scientists*, 17.
9. **Institute of phytopathological research (I.P.O.).** *Scientists*, 34. Long-term research on pests and diseases of major crops.
10. **Institute of agricultural engineering and rationalisation (I.L.R.).** *Scientists*, 20. Research, testing and improvement work on farm machinery, and research on labour management in agriculture.
11. **Institute of horticultural engineering (I.T.T.).** *Scientists*, 9. Research on and testing of technical aids and equipment in horticulture.
12. **Institute of research on storage and processing of agricultural produce (I.B.V.L.).** *Scientists*, 12.
13. **Institute of research on storage and processing of horticultural produce (I.B.V.T.).** *Scientists*, 15.
14. **Plant physiological research centre.** *Scientists*, 4. Advice and technical assistance to physiologists working in the field of agricultural research; research on physiological problems in agriculture.
15. **Institute for the application of atomic sciences in agriculture (I.T.A.L.).** *Scientists*, 4.
16. **Institute of Farm Building.** *Scientists*, 5.

III. *Other Government-sponsored Institutes:*

1. **Government seed testing station (R.P.Z.).** *Scientists*, 7.
2. **Plant protection service (P.D.).** *Scientists*, 27. Safeguarding the healthy condition of crops and inspection of exported and imported plant material.
3. **Institute for research on varieties of field crops (I.V.R.O.).** *Scientists*, 10. Evaluation of new varieties; compilation of the annual descriptive list of varieties of field crops.
4. **Institute for cereals, flour and bread (T.N.O.).** *Scientists*, 11. Research and advice on problems concerning the manufacture of cereals.
5. **Foundation for rural home economics research.** *Scientists*, 6.

IV. *Private Institutes*

1. **Laboratory of soil and crop testing, Oosterbeek.** *Scientists*, 6. Testing soil samples and chemical crop testing, in order to advise on the use of fertilisers, etc.; chemical research in this field.
2. **Netherlands institute for dairy research (N.I.Z.O.),** Ede. *Scientists*, 15.
3. **Plant nutrition research laboratory (Chilean nitrate agricultural service).** *Scientists*, 4.
4. **Research laboratory for agricultural chemistry and advisory office of the Netherlands superphosphate industry.** *Scientists*, 2.
5. **Agricultural office for basic slag.** *Scientists*, 2. Research and information centre for the application of basic slag in agriculture and horticulture.

*For full particulars, see: *Wageningen, Centre of Agricultural Science*, published annually by the International Agricultural Centre, 1 Generaal Foulkesweg, Wageningen, The Netherlands.

The Agriculture of Latin America

A modern Venezuelan rum and sugar refinery at Santa Teresa.

by **J. D. Waghorn,** *Shell International Chemical Company.*

To the outside world, the picture of Latin American agriculture is probably one of coffee and cocoa in Brazil, of beef cattle on the Argentine pampas, of sugar from Cuba, and of banana plantations in Central America. Much of the agricultural exports of the area are destined for the United States—indeed, it is from this region that that country obtains most of its tropical produce. But although export crops play a major part in the economy of many of the Latin American countries, they do not give a picture of the agriculture of this part of the world as a whole.

The greater part of the land masses that go to make up Latin America lie between the Tropics of Cancer and Capricorn, though to the north, half of Mexico, and to the south, virtually all of Argentina and Chile, lie outside the tropics. With these exceptions, Latin American agriculture is therefore tropical or sub-tropical. There are a few areas that are necessarily unproductive, such as the deserts of northern Mexico, the arid sandy littoral of Chile and the dry regions of southern Argentina, but of the remaining potentially productive area only five per cent is at present cultivated.

An important topographical feature that plays a significant part in determining the broad pattern of agriculture is the range of high mountains running from north to south through the region; one effect of this is that in some regions both temperate and tropical crops can be grown. The greater part of the remaining land area consists of undulating plateaux.

Broadly speaking, four different types of farming are carried on: by the subsistence farmer; by the smallholder working through co-operatives; by the plantation owner and rancher; and by very large estates. Subsistence farming still accounts for the largest cultivated acreage, except in the temperate regions. Highly organised plantations and ranches, some still run with foreign capital and all using the most modern methods, produce the bulk of the export crops. The large sugar estates in Cuba and the Dominican Republic, the banana plantations in the Caribbean countries, and the *estancias* of Argentina are examples of farm production on the grand scale.

Latin American trade has been dependent on crops that could be grown and on mineral deposits that would bring quick returns for the capital invested. Consequently, international economic factors have played a big part in determining the course of agricultural progress of the 20 Latin American republics. Countries such as Guatemala, Colombia, Ecuador and Argentina, which had no easily accessible mineral deposits of commercial importance, turned to agriculture; in Chile, Bolivia, Venezuela and, more recently, Mexico, minerals or oil are making major contributions towards the earning of foreign exchange. However, whether the principal export has been a product of agriculture or of mining, these countries have depended on one or two main commodities for their export earnings, and any fluctuation in world demand has had very severe effects on their national economies.

Industrialisation and the rising standard of living,

Subsistence farming in an Indian village in South America.

especially in the cities, has increased the demand for milk, meat and wheat; most of the tropical areas are not self-sufficient in these commodities, and deficiencies are made up by imports, mainly from the United States. The deficiency of livestock in the tropics is not confined to Latin America, and is due primarily to the difficulty of breeding strains that are efficient producers under tropical conditions. Nevertheless, the production of meat is increasing; the cattle industry of central and southern Brazil, for instance, now supplies the domestic needs of Brazil's 65 million inhabitants, and there is already a small, but increasing exportable surplus.

Coffee accounts for 80 per cent in value of the exports of Colombia and El Salvador; for over 60 per cent of the exports of Brazil, Haiti and Guatemala; and for over 40 per cent of the exports of Costa Rica and Nicaragua. Bananas earn virtually the entire foreign income of Panama, and about half of that of Costa Rica and Honduras. The place of sugar in Cuba's economy is well known. There are other crops that represent over a third of the exports of individual Latin American countries, but these examples serve to show how changes in world demand, or widespread damage to one crop, can effect a country's economy.

Thus, the present decline in coffee prices (due in part to increased production in Africa as well as in the New World) has severely strained the economies of Latin American coffee-producing countries. Again, gales that struck banana plantations during the past few years in Panama, Honduras, and the Dominican Republic have had a similar effect. And the recent decline in the price of sugar and raw cotton has greatly curtailed the purchasing power of Cuba and the Central American cotton-growing countries.

Although this reliance on one or two crops for export earnings obviously has its dangers, it has produced income for economic development on a scale that a more balanced agriculture could not possibly have done. Many governments are acutely aware of the hazards of their economies and are seeking to improve matters. For example, the signatories to the recently terminated World Sugar Agreement are likely to draft a new agreement in an endeavour to stabilise the price of sugar by the establishment of export quotas, among other proposals. Again, the recently negotiated Latin American Coffee Agreement has established export quotas based on each country's average exports over the three years preceding the 1957-58 crop. The cotton surplus will have to resolve itself in the light of the extent to which cotton is displaced by man-made fibres and the method of disposal of the United States cotton surplus.

At the inter-country trading level within Latin America there have been two principal trends of thought: first, that it is to the advantage of two countries to establish bilateral trade agreements—such as that between Argentina and Brazil for the exchange of wheat for tropical crops; and secondly, that free trade areas should be set up, as exemplified by the Multilateral Treaty of Free Trade and Central American Economic Integration, drawn up in

Spraying a South American tobacco plantation with insecticide.

Tegucigalpa, Honduras, last year, and awaiting final settlement. Argentina, Uruguay, Chile and Brazil are currently discussing a similar arrangement. Both policies have their advocates, but the one that is likely to be most profitable to any one country will depend on the prevailing pattern of international trade and politics.

At the internal economy level, many of these countries are actively working towards establishing a more balanced agricultural production, and towards raising the nutritional level of their population. With this end in view, land tenure reforms have been carried out in Mexico from time to time under the agrarian revolution of 1910, and are being continued under the Government of Senor Lopez Mateos. In Cuba, Dr. Castro has said that one of the primary objectives of his Government is agrarian reform, and he has already asked for European agriculturalists to advise on technical improvements. The Food and Agriculture Organization of the United Nations has also helped governments in economic surveys and made recommendations based on the findings.

Technical improvements over the past decade have dramatically raised the productivity of the principal crops grown in Latin America. These improvements have been brought about both by the firms who manufacture farm machinery and agricultural chemicals, and also by government encouragement. More often than not the two interests have worked closely together to encourage and finance the use of new methods and materials.

Argentine and Mexican wheat is now mostly harvested by combine, and it is not uncommon to see rice in Panama, or maize in Brazil, being mechanically cut. For the most part, however, the cultivation and harvesting of these latter crops are still not mechanised. Coffee, cocoa and bananas, both by the nature of their growth habits and of the terrain on which they are grown, do not easily lend themselves to mechanical cultivation or harvesting, and will continue to require a large amount of labour.

Use of chemical fertilisers and pesticides is increasing as well. Traditionally, Chilean nitrate was an important source of nitrogenous fertiliser. But recent increased awareness of the value of fertilisers has led to greater use even by small farmers, and to meet this demand nitrogenous fertilisers are now being manufactured in Brazil and Mexico. A plant is due to start production in Peru in the near future and an American concern is building a new factory in Trinidad for the supply of nitrogenous fertilisers to the Caribbean lands. These are only the beginnings of what is likely to become a vast new industry. Introduction of the newer pesticides has made a major contribution to raising the yields of crops and has allowed them to be grown on land that, but for these chemicals, would not produce a crop worth harvesting.

In Argentina a species of grasshopper, known locally as *tucura*, has caused untold damage to grassland and alfalfa, and the ravages of this pest have substantially increased the costs of raising cattle on the pampas. A modern insecticide has now brought about effective control. Cotton could not be grown in most parts of Latin America without the use

Typical Brahman cattle being herded for dipping.

of insecticides, and as many as 30 sprayings a season are made by aircraft to achieve control of pests such as the boll weevil. Bananas require—indeed must have—constant spraying with Bordeaux mixture or spray oils, if leaf spot disease is to be controlled. Ants of various kinds do serious damage to nearly all crops, and, in addition, infest rural dwellings and throw up their huge mud-heaps on the dry savannahs; now control can easily be achieved. Weedkillers, too, play their part in modern Latin American agriculture. But there is still a long way to go in expanding the use both of fertilisers and insecticides.

Research on plant breeding is being carried on in all the Latin American countries, with much help from United States missions. Such research stations as the Inter-American Institute of Agricultural Sciences at Turrialba in Costa Rica and the Departemento de Investigationes Agropecuarios in Colombia are making their contributions towards improved varieties, seed production and seed testing. Panama disease, which attacks the roots of the Gros Michel variety of banana, has made the production of this crop difficult in large areas of Central America, where once it flourished. There is no very satisfactory method of preventing or controlling this disease, and much work has been done in an endeavour to breed a resistant variety that produces fruit of the same size as the Gros Michel; only recently has a new strain of possible commercial value been evolved.

Rice in Cuba and Venezuela has suddenly become susceptible to the ravages of a virus disease known as *hoja blanca*, that is spread by the rice leafhopper. The use of pesticides, although reducing its incidence, has failed to give satisfactory control, and resistant varieties are being tested for cultivation in these regions.

Mention has already been made of the livestock industry in Brazil. Its success is due to the tireless efforts of farmers and government experimental stations in cross-breeding the humped Brahman cattle imported from India with breeds of good conformation and milk yields such as the Hereford and the Friesian, brought in from Europe. Similar work is being carried out in other countries in order to develop good economic cross breeds that are well adapted to their climatic conditions.

Latin America is, in fact, a region of vast agricultural potential—of contrasts between wealth and poverty, new methods and old. The future would seem to lie in improving the lot of the smallholder, both by encouraging him to use modern methods and by government investment in land clearance, irrigation schemes, better transport facilities and controlled marketing. The rate at which such improvements can be made will undoubtedly influence the part which Latin America will play in world affairs.

The above article was first published in The Times *special supplement on Latin America, 29th June, 1959, from which it is reproduced by permission of the Editor.*

The manuring of sugar cane

by **R. F. INNES**

Director of Research, Sugar Manufacturers' Association (of Jamaica) Ltd.

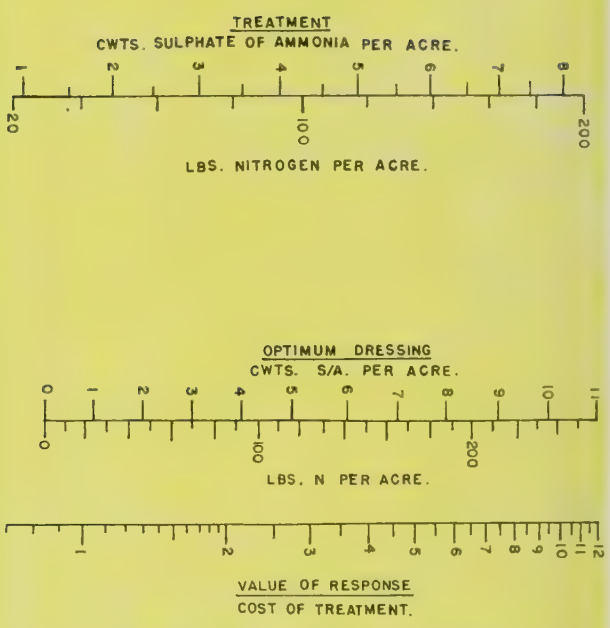


Fig. 1. Sugar cane: relationship between nitrogen response and the optimum dressing of nitrogen.

The total plant food removed from the soil in millable cane at harvest fluctuates widely depending on variety, soil, fertiliser policy and tonnage cut. While an average crop of 35 tons per acre of millable cane would contain about 40lb. nitrogen, 50lb. P_2O_5 and 130lb. K_2O, on heavily fertilised land producing high tonnages, the figure could be as high as 300lb. nitrogen, 180lb. P_2O_5 and 960lb. K_2O in a two-year crop. It is not surprising, therefore, that on most soils the continuous production of sugar cane leads sooner or later to the application of at least nitrogenous and potassic dressings.

The rate of uptake of nutrients increases rapidly during the first three months of growth and peak rates are reached between four and six months for annual cane; for cane grown for two years a second but lower peak is reached at around 16 months. Field experimentation in most countries has failed to produce evidence that fertiliser dressings—even nitrogen—are more beneficial when made in two or more applications, provided the first application was adequate and was made at between planting and six weeks for plant cane and soon after harvest for ratoons. Where deficiencies have developed in the standing crop, late applications of all three plant foods have beneficial effects; this applies particularly to nitrogen.

The size of dressings to be made is determined principally by soil type, available water, whether the crop is plants or ratoons, and the age of the cane at cutting. As a result of the statistical treatment of the published data of field experiments in British Commonwealth producing countries, it has been shown by HODNETT and others that yield response can be defined according to Mitscherlich response curves. These relationships, translated into cost of dressing and value of response, have been differentiated to give optimum economic dressings; the solution for different economic conditions and responses to standard dressings can be obtained by reference to the three nomograms (Figures I, II and III). The nomograms possess the advantage of allowing optimum economic dressings to be arrived at from a knowledge of the response to one level only of plant food.

Experimental evidence suggests that rarely are more than 150lb. nitrogen required per acre for 12 months cane, and that in plant cane, optimum dressings rarely exceed 80-100lb. nitrogen per acre; the figures may be as low as 40lb. per acre where water is inadequate. There is little difference between the value of nitrogen from different sources: where aqueous and anhydrous ammonia are economically competitive, they have been extensively used. These materials have not generally attained commercial significance on neutral or alkaline soils, nor on heavy clays.

Phosphatic, like potassic dressings, vary greatly with soil type, and may be as high as 110lb. P_2O_5 or more per acre per annum, although such levels are exceptional. Applications of up to 60lb. P_2O_5 are common. On acid soils finely ground rock phosphate is used at rates per acre of *up to* 500lb. P_2O_5, applied with the cane setts at planting and repeated at the next replanting. Potassic dressings usually vary between 1cwt. and 2cwt. per acre

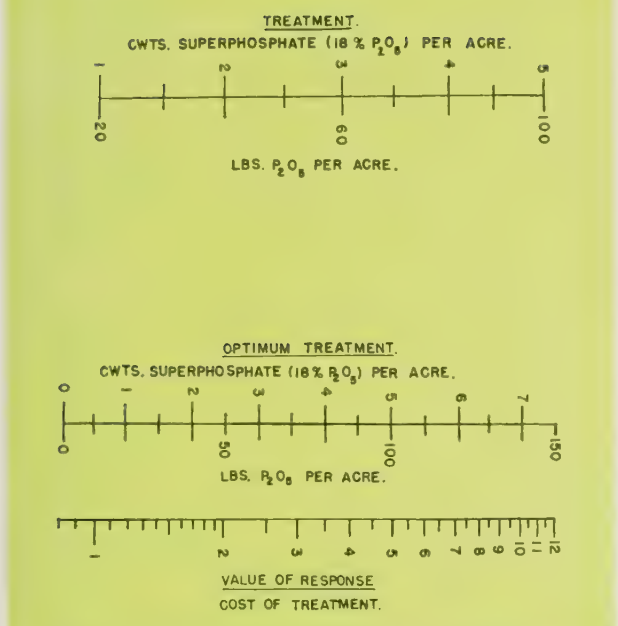


Fig. 2. Sugar cane: relationship between response to applied P_2O_5 and the optimum dressing of P_2O_5.

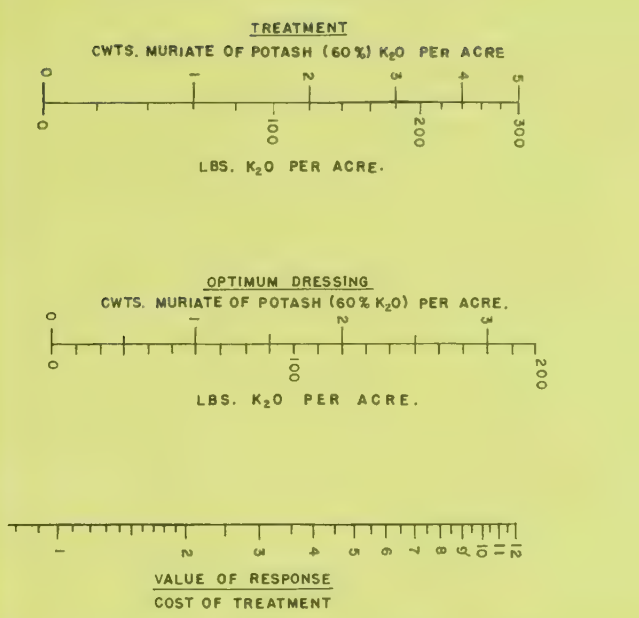

TREATMENT
CWTS. MURIATE OF POTASH (60 %) K_2O PER ACRE
LBS. K_2O PER ACRE.
OPTIMUM DRESSING
CWTS. MURIATE OF POTASH (60 % K_2O) PER ACRE.
LBS. K_2O PER ACRE.
VALUE OF RESPONSE
COST OF TREATMENT

Fig. 3. Sugar cane: relationship between response to applied K_2O and the optimum economic dressing of K_2O.

per annum of muriate of potash (60% K_2O); at the higher level, soil potash reserves are generally increased in Jamaican soils.

The interactions between major elements are rarely important where yield responses are concerned.

Placement

The placement of fertilisers may be important. Phosphate is usually placed in the root zone under the plant by applying the fertiliser with the sett at planting. Recent experience in Mauritius and South Africa suggests that, where trash is not burnt, there is merit in applying this plant food broadcast on the trash, to be absorbed by the surface roots feeding in the lower layers of the decomposing organic matter. On alkaline soils savings can be effected by drilling solid ammonium nitrogenous compounds into the soil, but these savings are not generally worth while unless the operation can be combined with inter-row cultivation. On heavy clay soils, the subsoil placement of nitrogen has been beneficial. For ratoons, and especially for the correction of a late appearing deficiency, both urea and muriate of potash can be applied aerially, while nitrogenous fertilisers can be distributed in surface or overhead irrigation water if the distribution of the water is fairly uniform.

Fertilisers influence the quality of the cane reaped An excess of nitrogen adversely affects quality, but while the responses in cane weight remain high, the adverse effects on quality remain small. The effects of potash are beneficial and particularly so over the range where yield of cane is also responding. The effects of both nitrogen and potash can be of economic importance but those of phosphate, although significantly adverse, are generally so small as to be of little consequence.

Deficiency Diagnosis

The methods of diagnosing sugar cane's nutritional requirements for major elements are quite advanced compared with most other crops. In well farmed fields, visual deficiency symptoms are very rare; when they occur they are usually associated with adverse rooting conditions. Acute nitrogen deficiency leads to a yellow-green coloration, progressive leaf drying beginning with the margin of the older leaves, stunting of growth and thin stalks.

In young shoots phosphorus deficiency can produce a lack of tillering and a purpling of the young leaves; in older cane the leaves are narrow and blue-green, the stalks thinner and shorter.

Potash deficiency symptoms start with a yellow spotting of the older leaves, the spots becoming orange and necrotic, and the leaf margins 'scorching' or 'firing'; the upper surfaces of the older midribs become pink, the younger internodes shortened and the stalks thin. The symptoms are sometimes confused with the damage from leaf-sucking insects. Leaf fungus attacks are aggravated by a potash deficiency.

Soil analytical techniques have been widely used, especially on base-deficient soils, but only for phosphorus and potassium. A Truog[1] or modified Truog extractant is

[1] Dilute ammonium bisulphate solution, pH3·0.

generally used for phosphorus and the figure of 40 p.p.m. available P_2O_5 appears to be fairly widely accepted; this is varied in some areas depending on the apparent density of the soil. Phosphate responses in yield have been shown to be a function of the extent by which the soil-available phosphate level falls below the critical limit. On soils possessing free lime, the reliability of Truog phosphate figures for diagnostic purposes is poor.

Both semi-normal acetic acid and normal ammonium acetate are used to determine soil-available potash. The critical limits for the former vary between 80 and 115 p.p.m. K_2O depending on the heaviness of soil texture, whilst for the latter 130 p.p.m. is used for base deficient soils, and up to 150 p.p.m. for soils containing free lime. Some workers find it also necessary to express potassium as a percentage of the total exchangeable cations. Yield response has been shown to bear a curve relationship to soil-available potash, and the decrease in soil-available potash with continuous cropping has been shown to be a linear function of the initial level of this plant food in the soil.

Tissue diagnostic methods are being increasingly applied to the control of sugar cane; in many countries they are the main diagnostic tool and have attained a high standard of accuracy. The most popular tissue is the lamina material of the first mature leaf or leaves, the N, P_2O_5 and K_2O per cent dry matter of which are referred to as N, P_2O_5 and K_2O indices. All indices vary with the age of the cane at sampling, with droughts, soil aeration and according to whether the crop is 'plants' or ratoons. For actively growing four to five months old cane it has been shown that leaf indices are logarithmically related to the soil-available supply of the plant food concerned; that yield response to a standard dressing of a plant food is logarithmically related to the leaf index in the absence of the dressing; and that relative yield response is linearly related to the relative response in leaf index as the result of applying a standard dressing of the nutrient.

The nitrogen index is the most sensitive to extraneous influence and therefore the most difficult to use; it is highly correlated with the moisture content of the sheath and is expressed at a standard sheath moisture by some workers. Phosphate is the next most reliable and potash the most reliable index.

There is a general measure of agreement between the limits established in several countries; the limits used in Jamaica are 1.90% N; 0.45-0.50% P_2O_5 and 1.40 to 1.50% K_2O. At or above the P_2O_5 and K_2O limits, dressings of either plant food do not influence leaf composition significantly, neither do they increase yield. The limits from a wide selection of ratoon fields which failed to respond to extra dressings of nutrients are given in the accompanying table.

Interest is not confined to leaf lamina material only. The stalk, being a storage tissue, is claimed to give warning of approaching deficiencies as a result of the withdrawal of plant food to more metabolically active centres; but so far, although stalk composition is more sensitive to variations in soil supply, there is no evidence to show that its composition correlates more closely with yield response. For potash, comparison of the ratio of the composition of the midrib sap of a newly matured leaf with that of a senescent leaf may well provide ease of sampling (with a good correlation with yield response) and early warning of an approaching deficiency state.

Recent tendencies in the control of nutrition on a plantation scale in Jamaica centre round the response in yield in a series of simple blocks of NP, NK, PK and control treatments, widely dispersed on the plantation, and in annual leaf composition surveys based upon sampling at four-and-a-half to five months, or at three and six months where analytical capacity permits. The surveys repeated annually give a dynamic picture of the changes in the plant nutrient supply position of soils, and fertiliser dressings are adjusted accordingly.

For Further Reading

For a more detailed account of the subject, readers are referred, amongst other publications, to the *Proceedings of the Congresses of the International Society of Sugar Cane Technologists;* the *Reports of the Experiment Station Committee of the Hawaiian Sugar Planters Association;* the *Annual Reports of the Sugar Cane Experiment Station, Mauritius:* the *Annual Reports of the South African Sugar Experiment Station;* and the *Proceedings of the Conference of the BWI Sugar Technologists.*

Table

The effect of age of sugar cane at sampling* upon the composition of leaf lamina dry matter of the third fully opened leaf—the values above which the response to applied plant food is negligible in ratoons.

Age in months	*% leaf lamina dry matter*		
	N	P_2O_5	K_2O
3	2.25	0.51	1.65
4	2.02	0.47	1.62
5	1.93	0.45	1.62
6	1.85	0.44	1.56
7.5	1.75	0.42	1.44
9	1.65	0.40	1.38

**The cane was not suffering from drought.*

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Agricultural Engineering Research in North America

by **J. A. C. Gibb,** *University of Reading.*

During the period August to October, 1958, the author visited a number of agricultural engineering teaching institutions, conferences and manufacturers in Canada and the USA. In the following article he summarises his impressions of research in this field.

Agricultural engineering research in America is a wide-ranging and extensive business. As in any other country, the three parties mainly concerned are the government, the universities and colleges, and the manufacturers. Apart from the sheer size of the American research programme in agricultural engineering, a striking factor is probably the large amount of co-operative work to be found.

The major part of the co-operative work is carried out by United States Department of Agriculture workers attached to university departments of agricultural engineering. In addition, however, one finds many examples of commercial manufacturers sponsoring specific university research projects. These are usually either of a rather fundamental nature which will yield information of general value, or may be of a short term applied nature which is relevant to the particular manufacturer's business. A third broad form of co-operation exists between groups of universities in given areas. These groups produce plans or other information related to the needs of the area—for example, the Canadian Farm Buildings Plan Service, or the Mid-West Plan Service, both of which are supported in the Farm Structures field by the universities in the areas concerned.

Research activities in general are, therefore, geared to meet specific needs. Information on a particular topic is required, money is made available on a thoroughly adequate scale, and the results are produced in quick time, as a matter of urgency.

In addition to the great volume of such work carried out by university agricultural engineering departments, much work of a more fundamental nature is also undertaken by graduate students. It is a fairly rigid rule, written or unwritten, that once a university staff-member has reached a certain status (such as assistant professor), he cannot carry out part-time work for higher degrees within his own faculty—as is the common practice in Great Britain. Thus he must obtain leave of absence and go to another university for one or two years, to work full-time on his higher degree study. Since it is increasingly becoming a prerequisite for promotion to the associate-professor grade (comparable to Lecturer, Grade I, in England) and beyond, to hold an M.Sc. or even a Ph.D. degree, there is a constant stream of candidates engaged in such graduate work.

Business and Research

Commercial organisations also have their own research divisions. In most cases these work in comparative secrecy, and are not prepared to welcome the casual visitor. Generally speaking, the work of such departments is more in the nature of development than true research, and is related to the future production plans of the firm concerned. Field testing of machinery is an important function of the research divisions, and in America the vast extent of the land mass, and the consequent wide spread of climate, allows 'seasonal' testing to be carried out over a conveniently long period, by moving north or south to find the required crop development stages. Commercially-sponsored research in the universities is welcome, on the whole, and should be of mutual advantage. Occasionally, however, the commercial support carries with it the

A 'flotation' vehicle (University of Massachusetts).

A tandem tractor (Michigan State University).

obligation to work in secrecy, which one would think to be foreign to the nature of a teaching institution basically supported by public funds.

Government research stations act mainly as headquarters for the Research Services, administering funds and research personnel seconded to the universities, and co-ordinating the national research programme. Some research is also carried out at these centres, such as the United States Department of Agriculture's Agricultural Research Service headquarters at Beltsville, Maryland.

More Power

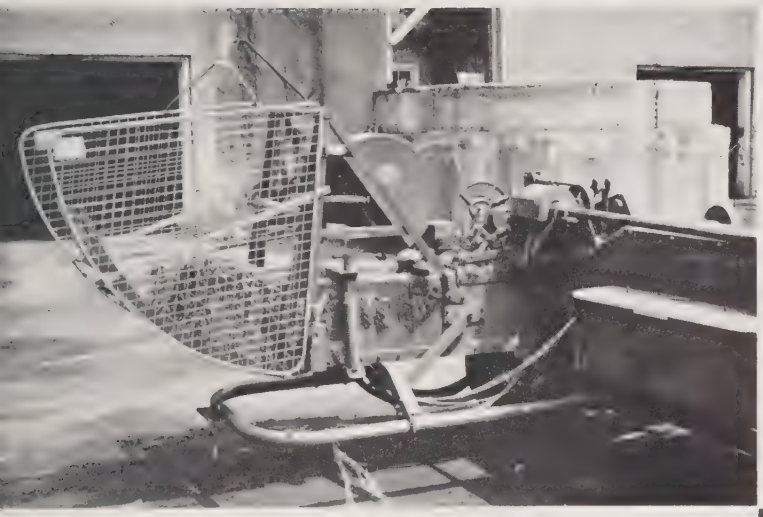
So much for the general picture. Other impressions are mainly those made by individual projects and experimental machines. The power requirements of agriculture, for instance, have been the subject of much experimental work. The tandem tractor has been suggested as a device to allow one operator to use a high-horsepower four-wheel-drive unit for rapid cultivations and seeding work. A single tractor developing perhaps over 100 BHP is unduly cumbersome and uneconomical in fuel consumption for the large majority of other farm tasks, so at the end of the planting season the tandem tractor is split into its component units. The perfecting of control arrangements, and rapid systems of joining and splitting the two tractors, has still to be worked out in detail, but the fact remains that the two normal tractors together cost less than the only available four-wheel-drive machines—necessarily indivisible—of a power equivalent to the tandem tractor. It seems clear that one can expect further work on this line.

Following from the increase in power, and therefore weight, of machinery, which is a prominent trend in farm equipment, some disquiet is being expressed regarding the effect this weight has in compacting the soil. Experiments are therefore being carried out with machines such as the 'flotation' vehicle. This is carried on very large low-pressure tyres which reduce the compaction effect to a minimum. A mounting is provided for a wheel and tyre of any desired type, to enable both weight and a scrubbing action to be applied to the soil, which is subsequently analysed. In another place, parallel work was in progress on the effect of various levels of consolidation on the germinative and growth capacities of seeds.

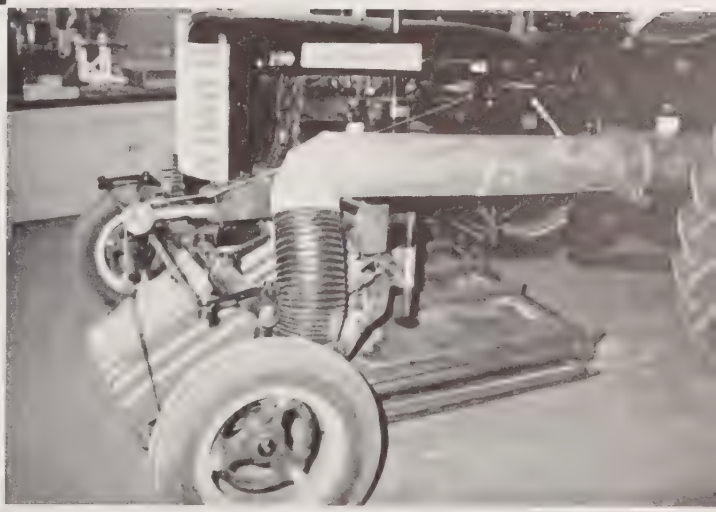
Storage and Handling

The storage of feeding-stuffs demands from many American farmers a large proportion of their labour and capital resources. Storage of 'corn' (maize) at high moisture content (to avoid the need to dry the crop), and silage at low moisture content (to provide a higher feeding value), calls for sealed silos. Vitreous-lined steel silos are available commercially at a rather high cost, and in many places experiments are in progress to ascertain both the basic requirements of such storage, and the practicability of cheaper alternative containers. In one instance fibreglass containers were in use, and a vibrator was installed to overcome the reluctance of the damp stored corn to flow out of the silo. In other cases, plastic linings were being tried, either in the form of a separate bag made of plastic film, or as a paint applied directly to the concrete silo side. Extracting the stored material in such a way

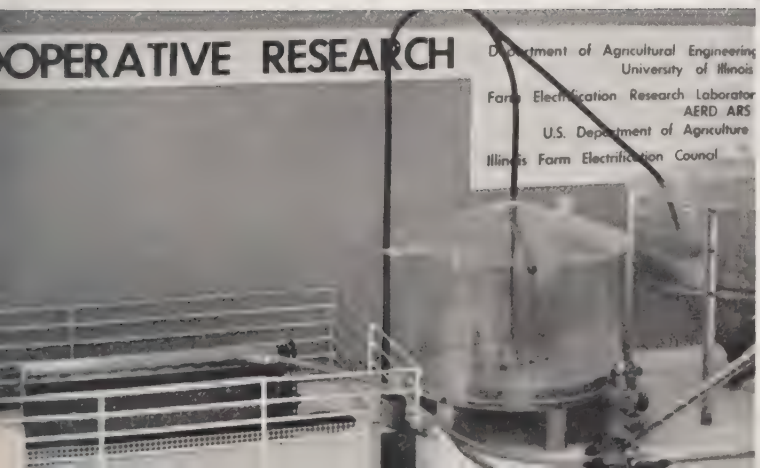
A home-made fork-lift truck, developed by a Canadian fruit grower.



A bale thrower, fitted to a pick-up baler (John Deere).



An experimental cucumber harvester (Michigan State University)



A model of a fully automatic animal feeding system (University of Illinois).

as to minimise the ingress of oxygen is also receiving attention.

Feeding hay or silage to cows or beef animals may be undertaken in several ways, but a simple device, suitable in some circumstances, is the self-feed wagon. This seems elementary enough, but in fact the design of the openings and shelf dimensions is quite critical if wastage is to be kept to a minimum. One university department which has developed an especially successful design values it particularly as a tangible contribution towards solving the feeding problems of farmers in its area, which in turn focuses goodwill and appreciation of their work on the university concerned.

Handling materials of all kinds on farms receives increasing attention, and more than one manufacturer now offers one-man handling of hay bales, from field to storage. While one maker has such a system in production already, it is very likely that further developments will follow. In this particular case the baler is fitted with a bale-thrower which throws bales of half normal length into a self-unloading trailer with high sides, towed behind the baler. At the farmyard, the bales are unloaded mechanically into the hopper of an elevator, which carries them up into the hay loft on the upper floor of a barn. There they are stacked at random, dropping at intervals from a conveyor carried in the apex of the roof.

Fork-truck techniques have not yet spread extensively on American farms, but fruit-growers are beginning to adopt pallet systems. A very creditable piece of development by a Canadian farmer is illustrated here—a home-made fork-life truck. On another Canadian farm, the owner's ingenuity was responsible for two self-propelled self-unloading lorries, constructed from proprietary bodies, such as that shown in the photograph of a 'flotation' vehicle, mounted on extensively modified truck chassis.

Honey Extraction

A number of research projects which were seen catered for unusual operations. One was at an apicultural laboratory, where mechanical honey-extraction equipment had been developed. Combs were loaded manually on to a conveyor, then passed mechanically through heated uncapping rollers to remove the wax sealing the cells, and into a centrifuge container. The filled containers were loaded manually into the centrifuge by means of a hoist. The extracted honey then ran down into a basement room for purification and packing into cans.

Cucumber Harvesting

At another university a research student was working on a mechanical cucumber harvester; this lifts the plants bodily, using suction to hold the leaves against the under side of a perforated conveyor. The cucumbers hang down and are knocked off and carried sideways by a conveyor.

Hay Pelleting

Two further topics of particular interest were encountered —hay pelleting, and automation. Pelleting is desirable only because once hay is compressed into pellets—which may be from 2 in. to 8 in. in diameter, and 2 in. to 4 in. thick—it can easily be handled by conveyors, under automatic control if necessary. The main problem is to obtain the necessary degree of compaction: 3,000lb. per sq. in. is stated by one of the commercial research departments to be necessary. Work on the fundamental properties of herbage, and the requirements basic to cohesion, is being undertaken at one university at least, and other commercially sponsored work on pelleting is believed to be in progress. In spite of the many technical difficulties that are apparent, it is clear that a practicable hay pelleting process will eventually be devised.

Automation

Complete automation of agricultural operations is not always to be desired at present. Even where push-button operation is already in use, as in many feeding installations, the extra cost of fully automatic control was not usually thought to be worth while. This was the case partly because it took a man little time and negligible effort to operate the control switches, and also because it was desirable that he should actually be on the spot and see the animals to check their condition.

One university department, however, has produced a full-scale automatic pig-feeding installation. An accompanying photograph shows a model of this, and also indicates clearly the three bodies responsible for this co-operative work. Basically, food is stored in two or more self-emptying containers, which are of sufficient size to hold two weeks' supply. Conveyors carry the materials to a blending and mixing mill, which delivers the ground material mixed as a ration containing the desired proportions of the constituents. The ration is blown to the feeding trough along a high-pressure, small-diameter pneumatic conveying system, incidentally receiving a static electrical charge to minimise dust by attracting the meal to the feeding trough. Time controls govern the operation of the complete sequence of operations, and a limit switch operates to stop the machinery when the hopper is filled. The pig accommodation consists of a covered eating-sleeping compartment, and a circular exercise and dunging yard. The exercise yard is washed down twice daily by rotating high-pressure water jets, removing the dung. In the event of a fault in any of the mechanism, a light mounted on the roof switches itself on to summon assistance.

This installation demonstrates that in certain circumstances full automation is possible. Whether farmers in general are prepared to trust automatic control devices without some further indication as to the well-being of their animals, is not at all certain.

This account of the kind of work being undertaken in the USA and Canada is necessarily very far from complete and lack of space does not permit many other interesting research projects to be mentioned. Nevertheless, it should be obvious that a great amount of valuable work is in progress, being carried out with considerable resources, skill and enthusiasm, and above all with a sense of urgency, in an endeavour to provide answers to the immediate problems of the American farming community.

A mosquito, Aëdes aegypti, *about to engorge human blood. This species transmits the causative virus of the urban form of yellow fever direct from man to man.*

A common South American monkey, Saimiri sciureus, *which is probably of importance in the epidemiology of yellow fever. It has been found to harbour antibodies to yellow fever virus in nature.* (Photo : Wellcome Museum of Medical Science.)

Yellow Fever under Control

by **William A. R. Thomson,** M.D., Editor, *The Practitioner.*

According to a recent issue of the WHO *Weekly Epidemiological Record*, in 1958, only 56 cases of jungle yellow fever were notified in South America and 75 cases in Africa. This is a striking tribute to the efficacy of the methods which have been introduced for the control of a disease which within living memory was one of the major scourges of West Africa and one of the major public health hazards of the central part of the American Continent.

Although it may not be able to claim the antiquity of some of the major pestilences of the world—the first authenticated epidemic occurred in Yucatan in 1648—during the last three hundred years it has claimed more than its fair share of victims. In the United States of America alone, for instance, it has been estimated that there were at least 500,000 cases between 1793 and 1900. It is just 80 years since there was an epidemic in Memphis, Tennessee, involving 17,600 cases, 5,150 of which proved fatal. Europe has not been immune from its ravages, the outstanding epidemics being the great outbreak in Spain in 1800 which caused 60,000 deaths, and that in Lisbon in 1859 in which 6,000 died of the disease.

Spain and Portugal, of course, were particularly vulnerable because of their close trading association with Central and South America. Epidemics were common in sailing vessels on the trade routes between Europe and America, presumably as a result of the mosquito-carrier of the disease, *Aëdes aegypti*, breeding in the ship's water vats. The United Kingdom was not immune from yellow fever: in 1865, the sailing vessel, *Hecla*, brought the disease from Cuba to Swansea where it was responsible for 13 deaths. The reason why the disease did not spread is the scarcity in the British Isles of mosquitoes which are capable of transmitting it.

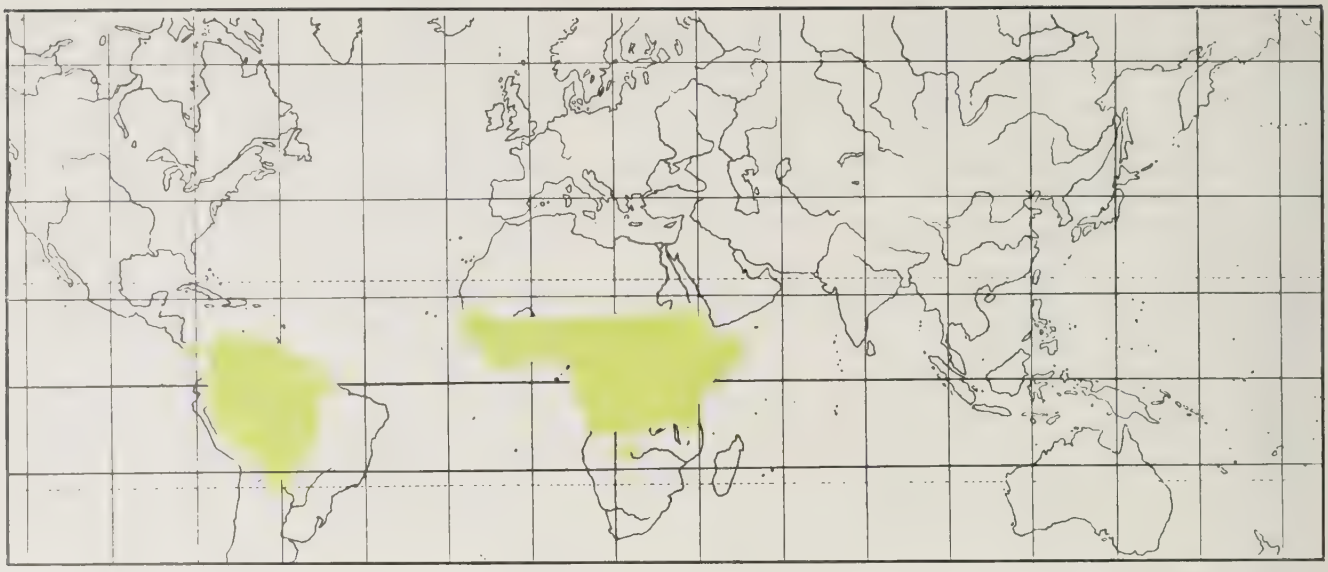
That the disease is by no means of mere academic interest at the present day is demonstrated by the fact that it is just over 30 years since there was a major epidemic in Rio de Janeiro. The classical example, however, of its devastating power was the predominant role it played in de Lessep's failure to build the Panama Canal. The subsequent success of the Americans in completing this great venture was due to the discovery that yellow fever was transmitted by a mosquito. This discovery opened up a new era in the control of the disease and has led during the last 50 years to the happy position we are in today, although, as we shall see, our present freedom from the disease is entirely dependent upon constant vigilance.

As shown in the accompanying map the distribution of the disease today is largely limited to parts of South and Central America and Africa. In America this zone includes the major portion of the Amazon and Orinocco basins, the greater part of Columbia, Panama and the Guianas. In Africa it stretches practically from coast to coast but—a point of considerable epidemiological significance—there have never been any extensive epidemic foci in the East African ports. The northern boundary is clearly demarcated by the Sahara. The southern boundary, however, is not so well marked, but it extends into Northern Rhodesia.

The disease is caused by a virus, with a diameter of 17 to 25 millimicrons (a millimicron is one-millionth part of a millimetre), which is related to the virus of dengue. The virus is transmitted by mosquitoes, the most important one being *Aëdes aegypti.*

Urban and Jungle Forms

Although yellow fever is due to a single virus, the disease occurs in two different epidemiological patterns, known as the urban and jungle forms. In the urban form the disease is transmitted direct from man to man by *Aëdes aegypti.* The mosquito becomes infected by biting a patient during the first three days of the disease. The virus then multiplies within the mosquito and approximately 12 days have to pass before it can transmit the infection by biting. Once infected the mosquito remains infective for life but suffers



Yellow fever endemic areas: a map prepared by WHO in 1955.

no ill effect from being infected. There is no evidence that the virus can be transmitted to the next generation through the egg.

In jungle yellow fever the monkey is the reservoir of the disease, although other forest animals such as the opossum and the marmoset may also act as reservoirs. The discovery of the course of infection in jungle yellow fever is a fascinating story, and the sequence of events is best illustrated by what happens in Africa. Two mosquitoes are involved—*Aëdes africanus* and *Aëdes simpsoni*. The former lives in the tree-tops of the African forest and comes to life at night. The latter is active by day and is found in and around native plantations. When the monkey retires to the tree-tops for the night he is liable to be bitten by *Aëdes aegypti*. If the mosquito, or mosquitoes, that bite him are infected with the yellow fever virus, then the monkey acquires the disease. During the daytime one of the monkey's favourite pastimes is marauding native plantations. Here he is liable to be bitten by a mosquito which is active by day and lives at ground level—*Aëdes simpsoni*. If this mosquito, which is entirely eclectic in its biting habits, becomes infected by biting an infected monkey it then passes the infection on to any human being it may bite. In this way, as is shown in the accompanying diagram, we get the cycle of mosquito→monkey→mosquito→man, as opposed to the direct cycle of mosquito→man in the case of urban yellow fever.

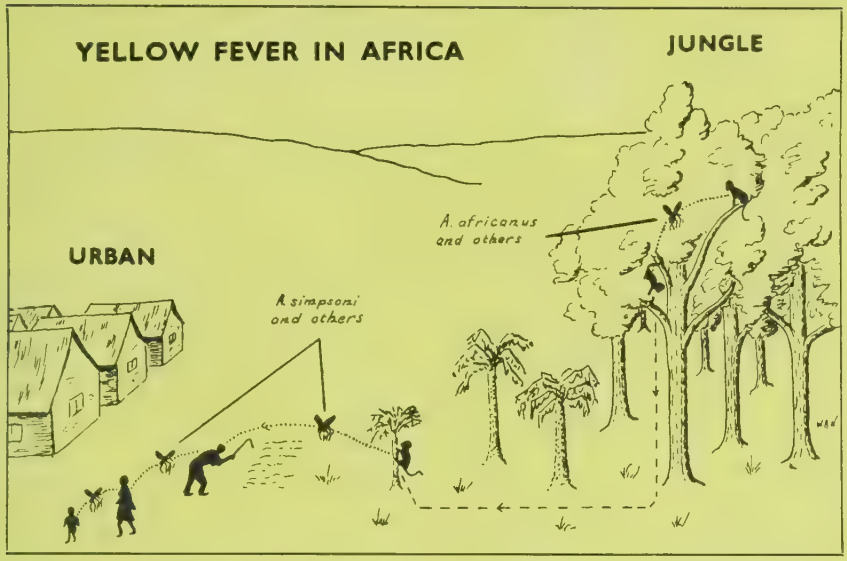
It is this persisting reservoir of infection in the forests of tropical Africa and Central and South America that constitutes the potential danger at the present day and requires that the strictest controls be maintained against the disease. That the danger is a very real one is illustrated by the fact that a wave of virulent jungle yellow fever is sweeping over Central America at the moment, practically annihilating the monkey population in certain areas. It started in eastern Panama in 1948 and has now reached the forests of Mexico. Fortunately, there are grounds for believing that it may now be coming to an end. In spite of the heavy death-roll among monkeys, there have been relatively few cases in man, but this is entirely due to the activity of the public health authorities and the efficiency of current methods of prevention.

Two Control Methods

For all practical purposes there are two methods of controlling yellow fever: eradication of the mosquito-vector, and vaccination. For long we were entirely dependent upon the former and that it could be effective is well exemplified by the success of the Americans in building the Panama Canal. In the early days preventive measures were confined to the control of breeding, which was achieved by a weekly search for larvae in and around all houses, and inspectors had authority to pour oil into any containers found to harbour larvae of *Aëdes aegypti*. This somewhat drastic action had a most beneficial double effect: it not only killed off the larvae but also compelled the householder to clean the container. Anyone who has attempted to clean anything like a water-vat after oil has been poured into it will appreciate that no more effective measure could be imagined to impress upon householders the advantages of doing everything possible to prevent mosquito-breeding in and around their property.

Use of Insecticides

The introduction of the newer insecticides has, of course, simplified the control of yellow fever tremendously. One of their great advantages is that they are so quickly effective. Marked reduction of adult mosquitoes occurs almost at once, whereas anti-larval measures required about six weeks to reduce the mosquito population below the critical level. Unfortunately, they suffer from the same disadvantage as antibiotics—that certain insects are resistant to them. This means that as the susceptible ones are killed off, we are left with an insect population which is insecticide-resistant. Fortunately, if an insect, be it a mosquito or any other species, is resistant to one insecticide it is usually susceptible to some other. DDT was the first of the newer insecticides to be used on a world-wide scale, which is why we are now hearing so much about resistance to it. Thanks to the perseverance and ingenuity of the



This sketch illustrates the cycle of infection of yellow fever. In the case of the jungle form of the disease, the reservoir of the yellow fever virus in Central Africa is probably Aëdes africanus, *which maintains a cycle of the virus in monkeys; these animals maraud plantations, infecting* A. simpsoni, *which in turn infect man.* (Photo : Wellcome Museum of Medical Science.)

scientists, other equally effective insecticides are now forthcoming, such as dieldrin, which are proving of outstanding value in disposing of those insects which are resistant to DDT.

Vaccination

Whilst such measures are most effective in the case of urban yellow fever they are of relatively little value in controlling jungle yellow fever. To spray the tropical forests of Central Africa and America is scarcely a practical proposition. Fortunately, the introduction of an efficient and safe vaccine provided a most efficient alternative method of control. There are two main types of vaccine: the so-called 17D vaccine, which is given by subcutaneous injection and which is the one used in this country, and the French vaccine which is used by applying it to the scarified skin. The latter is slightly more efficient but is more liable to cause adverse reactions. Its great advantage is that it can be more easily administered and is therefore more suitable for mass immunisation campaigns such as those necessary in the affected areas of Africa. The French Government, for instance, has embarked on a campaign of vaccinating every person in their colonies in the yellow fever area every four years.

After subcutaneous inoculation with 17D vaccine, antibodies develop within seven to 10 days, and persist for up to nine years. It is on this basis that for most countries yellow fever vaccination certificates are valid 10 days after vaccination and thereafter for six years. On revaccination within six years the certificate is immediately valid and lasts for another six years. Most countries exclude infants up to the age of six months or one year from yellow fever vaccination certificate requirements. This is partly because vaccination at this age is not so effective as in later life, and partly because of the slightly increased risk of adverse effects.

Asian Paradox

The strict insistence upon the observation of the yellow fever vaccination regulations is no shibboleth of the official mind. Neither is it done merely for the protection of the traveller. The fundamental reason is to protect other parts of the world—and particularly India and the Far East—from invasion by the yellow fever virus, with all the dread consequences that this might have for the teeming millions of these Asian countries. Why such spread of the virus has never taken place is one of the most puzzling features of the disease. After all, *Aëdes aegypti*—and other mosquitoes—are capable of transmitting the disease wherever they may be found—and they are found throughout India and the Far East—and it is obviously essential to prevent the virus gaining admission to these areas. Practical confirmation of this has been obtained by bringing mosquitoes from India and Malaya to Africa where, under laboratory control, it has been shown that they are as good vectors of the disease as the African varieties. One possible explanation is that other diseases transmitted by the Asian mosquitoes, such as dengue, may interfere with the multiplication of the yellow fever virus in the mosquito and thereby prevent its infecting those whom it bites.

The introduction of air travel has considerably enhanced the risks as it means that a person infected with yellow fever in an endemic area could easily reach non-endemic areas within the incubation period of the disease in three to six days. Indeed, theoretically, even the UK is not immune from the risk. *Aëdes* (*F.*) *geniculatus*, which is plentiful in warm weather in woodland areas in this country, has been shown to be a most efficient vector of the disease. If, therefore, an infected traveller were to arrive in this country and be bitten by this mosquito, there is no reason why the mosquito should not transmit the disease to others in the area.

It is for these reasons that all the protective measures now in use should be maintained. These include the quarantine of potentially infected travellers, the eradication of *Aëdes aegypti* from airports, the spraying of aircraft with insecticides, and vaccination of travellers to and from endemic areas. In yellow fever, as in so many other facets of life, the price of freedom is eternal vigilance.

An adult cotton stainer, Dysdercus *sp.*

Chemicals for Cotton Pest Control

by **N. M. G. Bell,** *Shell International Chemical Company Representative in the Sudan.*

Cotton holds an essential position in world economy as the most widely used clothing material; besides this, some grades are valuable in various branches of industry. In consequence, cotton has become the world's major cash crop, with a vital part to play in the economies of a number of producing countries.

Because of its importance the economic outlook for cotton is worth considering briefly. Since 1956/1957 consumption has been greater than production; in the same period world stocks of raw cotton have been falling, mainly as the result of American stocks being reduced. Nevertheless, the stocks remain at approximately 50 per cent of the world annual consumption. Prices for raw cotton have varied considerably during the past 10 years, and recently there has been a definite downward trend. Since the peak in 1951 prices have fallen by about 50 per cent, and this trend has been especially marked recently for the longer staple cottons. It would seem, therefore, that the grower may look to a steadily improving demand for medium-long cotton but, because there is still scope for a considerable reduction in world stocks, particularly in the main producing countries, prices may continue weak.

Today, therefore, the grower's aim should be to exploit his crop so as to increase the proportion of higher grades and to raise yields considerably above previous levels. The net effect must be to raise income by at least the amount lost through the fall in price; even after any extra costs which may arise have been paid.

Thorough soil preparation and the adequate application of fertilisers, the use of good quality seed and the correct timing of the planting date, are still basic to good cotton cultivation. In addition, in recent years the correct use of chemicals to control the pests, diseases and weeds of cotton has been carefully studied and the discoveries which have resulted now enable the grower to improve his yields greatly.

Insect Pests

Wherever cotton is cultivated foliage pests are highly destructive, and in areas where no steps are taken to prevent damage foliage insects are usually the most important cause of crop loss. Even when insecticides are carefully used the losses may be substantial; for instance, in the USA the average annual loss is estimated at about 12 per cent, of which the boll weevil, *Anthonomus grandis*, causes nearly 10 per cent. Comparable nation-wide figures are not available for other countries but the conclusion to be drawn from trials with foliage insecticides, conducted all over the world, is that insects destroy a tremendous quantity of cotton each year.

Some people suggest that the use of chemicals in agriculture interferes adversely with the balance of nature and exposes consumers and those who apply the chemicals to unnecessary risk. There is no evidence, however, that such statements are true. Only a few simple precautions need to be taken for any pesticide on the market today to be applied with complete safety.

The following examples of ways in which pesticides can help in the cultivation of cotton are of interest:—

The control of *Aphis gossypii* in Brazil raised yields by 50-100 per cent (3).

The control of insect complexes, mainly boll worms,

Diparopsis, *Earias*, *Heliothis* spp., etc., raised yields by 36 per cent in the Central African Republic (1) and by about 50 per cent in Southern Rhodesia (8).

Controlling the spiny boll worm, *Earias insulana*, and the spider mite, *Tetranychus telarius*, in Iran produced yield increases of over 300 per cent (9).

In India, boll worm control resulted in increases of 40-160 per cent (7).

In Taiwan an increase of 2,600lb. seed cotton per acre (500 per cent) was recorded after boll worm and leaf hopper control had been obtained (4).

In each of the instances quoted here, the insecticide used was endrin, applied at normal low dosage rates (though in Iran Systox was added to control the spider mites).

Where damage by a complex of insects limits yields, particularly when boll worms or leaf worms are dominating, endrin is outstandingly valuable, its great advantages in such circumstances being its wide spectrum of kill at low dosages and its persistence—it normally gives protection for two to three weeks, although under some circumstances, especially if heavy rain falls directly after application, its residual life may be curtailed.

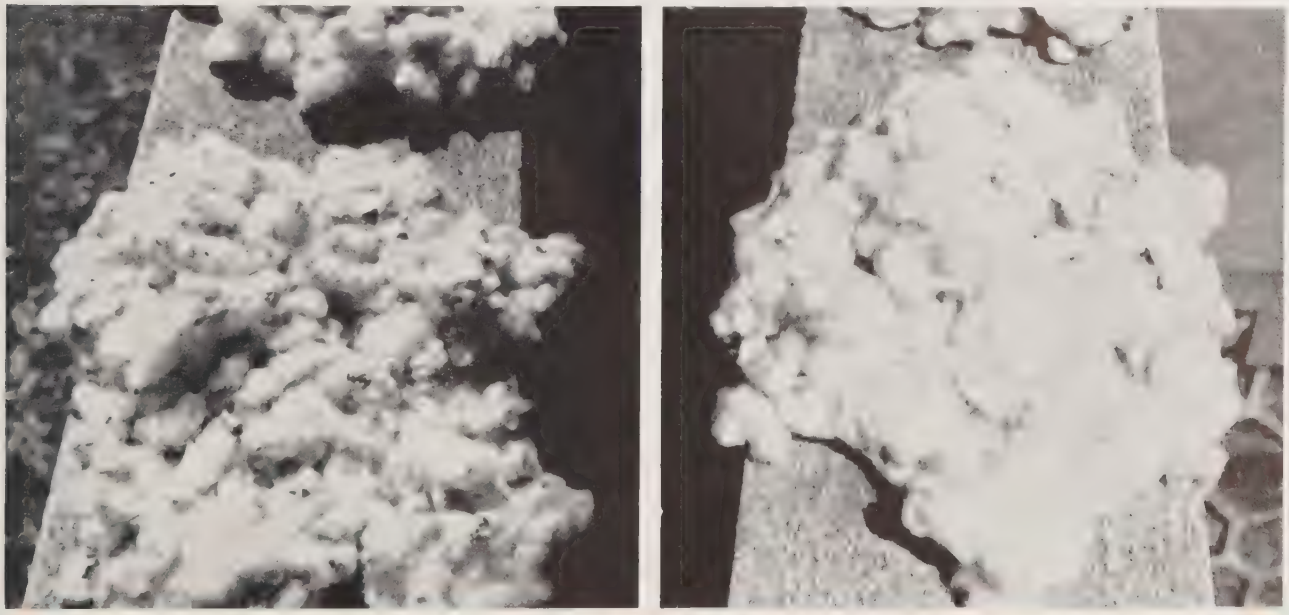
Among the important lepidopterous pests which endrin will usually control at rates of 0.25-0.5lb. active ingredient per acre, are boll worms—*Diparopsis castanea*, *D. watersi*, *Earias fabia*, *E. insulana*, *Heliothis armigera*, *H. virescens*, *H. zea* and *Sacadodes pyralis*; leaf-worms—*Alabama argillacea*, *Anomis texana*, *Prodenia litura*, *Laphygma exigua*, *L. frugiperda*, and the leaf roller, *Sylepta derogata*. Against the pink boll worm, *Platyedra gossypiella*, endrin alone is not always completely successful[1] and therefore up to 2lb. per acre DDT is sometimes added, the two insecticides being applied together (6).

Where boll weevils, *Anthonomus* spp., are important pests aldrin at 0.25-0.33lb., dieldrin at 0.15-0.3lb., or endrin at 0.2-0.4lb. per acre can be used to obtain good control. Thorough, well timed applications are the key to success.

Against aphids, *Aphis gossypii*, endrin is normally most effective when applied before pest numbers increase; such treatment using 0.25-0.5lb. per acre so that the crop is effectively covered prevents the population from building up. For controlling white flies, *Bemisia gossypiperda*, endrin is the best chemical available. Extensive use has shown that at 0.25-0.5lb. per acre endrin reduces the populations of white flies to a very low level at which they remain for some weeks.

Infestations of jassids, or leaf hoppers, *Chlorita*, *Dikraneura* and *Empoasca* spp., are also quickly eliminated by endrin but experimental work suggests that when dosage rates of 0.2-0.25lb. per acre are used really thorough

1. But endrin alone has been used successfully to control *P. gossypiella* adults and to reduce oviposition (10).



Two samples of native cotton grown on adjacent plots in the Ivory Coast. Note the poor quality of the left-hand sample, due to bollworm attack. The superior sample on the right came from an endrin-treated crop.

Striking evidence of the value of nematode control in cotton. The healthy part of this crop is growing in soil treated with Nemagon Soil Fumigant; the centre part of the field was untreated. The treatment was 1 US gal. Nemagon per acre, applied in the row before planting.

A native cotton market in the Tchad area, French Equatorial Africa.

Larvae of the cotton worm, Alabama argilla *Hubn., attacking a co plant.* A. argillacea *is important pest of cotto the Ameri*

coverage is necessary; for low volume tractor spraying 0.4-0.5lb. endrin per acre is desirable.

Cotton stainers, *Dysdercus* spp., and other plant bugs, for instance, *Creontiades* spp., *Helopeltis schoutedeni*, *Lygus* spp., *Nezara viridula*, *Oxycarenus* spp., and *Psallus seriatus*, are also pests against which dieldrin or endrin give good results. Aldrin is also often effective, when used at 0.25-0.75lb. per acre. The dieldrin or endrin dosage rate is 0.25-0.5lb. per acre, although for *Psallus* 0.1-0.3lb. is effective. Against *Nezara* about 0.5lb. endrin is the preferred treatment.

Another group of insects, which are mainly important on young cotton, are thrips, *Thysanoptera*; these pests are readily killed by dieldrin at 0.05-0.2lb. or endrin 0.08-0.2lb. per acre. Aldrin at 0.1lb. per acre is also very effective but less persistent.

Endrin at 0.25-0.5lb. also controls the broad mite, *Hemitarsonemus latus*, and dieldrin at 0.5lb. per acre is often successful. Against spider mites, *Tetranychidae*, chlorinated hydrocarbon insecticides are not effective. Where these pests cause important damage a suitable acaricide should be included in the treatment schedule.

Application

In a single article specific recommendations to meet all requirements cannot be given, and ranges of dosage rates have therefore been indicated. Generally, the lower rate is used while the crop is young and the higher rate when it is tall and dense. At the same time the volume of spray liquid applied is usually raised as the season progresses. When a particularly heavy insect attack is experienced the highest suggested rate should be used.

No inflexible rule can be laid down for the best means of applying insecticide to control foliage insect pests. Excellent results can be obtained with shoulder, tractor, or aircraft mounted machines; and both sprays and dusts

have been used most satisfactorily. A wide range of formulations enables the grower to make the most of whatever machinery is available. What is essential is that the crop foliage is thoroughly covered.

Besides ensuring good coverage at the correct dosage rate, it is important to time the application to coincide with the build-up of pests. Timing depends on local knowledge and on pest population dynamics: when numbers are increasing slowly it is normally only necessary to treat when significant damage is beginning to appear, but when numbers are increasing rapidly treatment must anticipate the onset of serious damage. To delay until widespread symptoms are apparent is likely to result in a serious loss of crop before treatment is complete. Regular insect counts, unless some more satisfactory system is available, are the means to successful timing. Good timing also ensures the optimum and most economic use of insecticide; and by avoiding the indiscriminate application of chemicals the likelihood of harming the beneficial insects which prey on cotton pests is reduced.

Resistance

In certain fairly clearly defined areas, mainly in North and South America, as a result of insecticides being used for the past several seasons, a few species which damage cotton foliage have become resistant to chlorinated hydrocarbon insecticides. In such cases an organo-phosphorus insecticide should be used—methyl parathion, for example, at 0.2-0.5lb. active ingredient per acre has often been found satisfactory. If there is a complex of cotton pests to be controlled, of which one or two are resistant, it is advisable to apply a mixture of methyl parathion and endrin (the endrin should still be used because it is more persistent than the organo-phosphorus compounds and will therefore keep down the populations of non-resistant pests for a longer period). When such a mixture is used do not reduce the dosages of either product because neither will be fully effective at lowered rates.

In some instances it may be advantageous to apply endrin and methyl parathion alternately, particularly where methyl parathion is highly effective against the resistant pest and renewed build-up after application is slow.

Soil Pests

The importance of soil insect pests tends to be neglected because they cannot easily be found before sowing and cannot be effectively treated afterwards. Where for instance wireworms, whitegrubs, termites, ant-mealy bug complexes, or millepedes cause regular damage a soil treatment with aldrin at 2-4lb. active ingredient per acre, or dieldrin at half the rate, should be made during the final cultivation. Alternatively, when fertilisers are used before planting, apply an aldrin-fertiliser or dieldrin-fertiliser mixture. As the same insecticide application rate should be used it is important to ensure that the correct proportion is present in the mixture. Insecticide-fertiliser mixtures can be obtained already formulated or they can be made up on the farm.

Non-phytotoxic insecticides can also be applied to the soil as seed dressings. The technique has the limitation that only the immediate neighbourhood of the seed is protected, so that in the event of a bad pest attack only partial protection is obtained but it is, nevertheless, highly advantageous in establishing seedlings. Experiments in Turkey during 1958 proved the value of seed treatment with aldrin 40 per cent wettable powder using up to 6.5oz. active ingredient per 100lb. seed. Losses from cutworms, *Agrotis ypsilon*, which were substantial in the untreated crop, were minimal in fields sown with treated seed, and yield was increased from about 360lb. to 1,200lb. seed cotton per acre.

Termites, wireworms, stem borers and millepedes are among the other soil pests that can be controlled with seed dressings. Although insecticidal seed dressings can be applied (as in Turkey) as a wettable powder, application costs can be substantially reduced if a dual-purpose seed

dressing containing both insecticide and fungicide is used, since cotton seed is almost invariably treated with a fungicide.

Nematodes

During the past two or three years, nematodes as pests of cotton have been receiving increased attention from research workers and growers. These minute soil organisms —their average size is only about $\frac{1}{25}$in. (1mm.)—are difficult to detect and consequently tend to remain unnoticed. But they are extremely important pests which can cause an overall loss in yield of 5-10 per cent, or as much as 50 per cent in heavily infested areas.

Usually nematode infested plants are not killed, and symptoms of attack can be confused with drought, mineral deficiencies, lack of organic soil constituents, waterlogging and so on. In the field, patches are found of stunted, wilted, chlorotic or generally unthrifty cotton.

Cotton root nematodes may produce open lesions on the roots or they may kill the fine feeder roots and lateral rootlets. Direct damage by impairing root spread, and thus the plant's ability to take up water and nutrients, weakens growth and severely reduces yields; it also enables pathogenic organisms, particularly fungi, to invade more easily the wounded tissues.

The nematode-*Fusarium* wilt complex is a well-known example of fungal attack following initial nematode damage. Wilt resistance in a given cotton variety, in fact, depends at least partially on that variety's ability to resist nematode attack, and where resistance has broken down a heavy attack of nematodes can usually be demonstrated. In this connection, experimental work in which cotton was planted in sterilised soil, part of which remained uninfected and part of which was intentionally infested with nematodes or *Fusarium* or both, produced the following results:

Nematodes	*Fusarium*	*Wilt*
Nil	Nil	0%
Added	Nil	1.2%
Nil	Added	2.5%
Added	Added	69.0%

From this it is clear that nematodes are directly associated with wilt (2).

The following nematode species have up to now been found responsible for damage by a nematode-*Fusarium* complex: *Meloidogyne*, *Belonolaimus*, *Tylenchorynchus*, *Trichodorus* and *Rotylenchulus* spp.; and recent evidence in Madagascar indicates that *Pratylenchus delattrei* and *Hoplolaimus seinhorsti* could also be important (5).

Experiments in the Americas have proved that nematodes can be controlled and valuable improvements in grade and yield obtained by applying the fumigant, Nemagon,* to the soil before planting. Trials in Mexico during 1958 gave the following results:—

*Nemagon is a Shell trade mark.

Comparative production of seed cotton in soils treated with different dosages of Nemagon

Nemagon dosage and method of treatment	*1st picking seed cotton kg./acre**	*2nd picking seed cotton kg./acre**	*Total*	*% of production 1st picking*
Dry Soil				
Untreated	270	182.5	452.5	60
½ gallon/acre row	935	277	1,212	77
¾ gallon/acre row	987	268	1,255	79
1 gallon/acre row	1,010	272.5	1,282.5	79
Untreated	182.5	172.5	355	51
1 gallon/acre broadcast	815	385	1,200	68
Moist Soil				
Untreated	343	217	560	61
½ gallon/acre row	1,072	320	1,392	77
¾ gallon/acre row	870	225	1,095	79
1 gallon/acre row	895	205	1,100	81
Untreated	230	267.5	497.5	46
1 gallon/acre broadcast	822	532	1,354	66

*Average of four replicates

These figures show that the yields of cotton from the treated plots are considerably greater than from the untreated controls. Of considerable importance is the fact that 180 days after sowing the treated plots had yielded nearly 80 per cent of all the cotton crop as against about 55 per cent in the case of untreated plots. A further advantage noted for Nemagon treatment was the fact that due to faster growth the following cultural practices could be dispensed with in the treated plots: two weedings, two cultivations and one irrigation. Together these comprise a valuable saving to the grower.

As a result of these and other similar trials it is recommended that ½-1 gal. Nemagon per acre should be used where there are indications of nematode attack on cotton. The simplest method is to apply the fumigant when the seed beds are being prepared, with tractor-mounted injection equipment.

The foregoing does no more than touch on some aspects of cotton pest and disease control. The intention has been to indicate some ways in which yields and grades can be improved to meet the market trends which can be expected.

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How Television Can Help Agriculture

Starling control—the subject of a West German television programme. The killing of starlings is forbidden in West Germany; this picture shows various methods used to frighten the birds away.

by **Mervyn Reeves,** *Head of FATIS*[1] *Unit, Division for Technical Action and Productivity in Agriculture and Food, European Productivity Agency, OEEC*

Television services establish themselves in densely populated areas and much of their early development is associated with urban interests. The extent to which the services should produce programmes directed to rural audiences—notably farmers, farmworkers and their families—is, therefore, a question of some interest, particularly to those who look to television as a potential force in agricultural education and advisory work, as well as a medium of public relations for the agricultural industry.

An excellent opportunity to review the present stage of development in a number of countries in farm television was provided recently by a conference on Television in Agricultural Advisory Work. Organised by the Midland Region of the British Broadcasting Corporation in Birmingham, on behalf of the European Productivity Agency under the FATIS Project, it was attended by participants from 12 OEEC Member countries, as well as by representatives from the United States and Canada. (A full report of the conference will shortly be published as a supplement to the *FATIS Review*.)

It might be thought that the title of the conference was somewhat limiting. But this was deliberately chosen to focus maximum attention on an important, specific use of television, so as to avoid too general and diffuse an approach. In the event, there was a variety of discussion on many aspects of farm television—programme construction, production personnel, costs, sources of programme material and so on—relating to a range of rural interests; for in many countries, the applications of television in a rural context—farm, home and community life—are closely interrelated.

Although items of interest to farmers of a technical or economic nature form part of the programmes of most countries, the 'service' programme which makes no deliberate concession to urban viewers is not common. The need to promote development in television services and the necessity to cover high costs of transmission by attracting the maximum number of viewers and licence holders are not easily reconciled with a policy of catering for the professional interests of minority groups—least of all those with limited numbers of receiving sets. It is quite certain, however, that television receivers will become widespread in the countryside during the next few years in Europe, and will eventually be as common in farm homes as is the radio. The coverage of rural areas by existing transmitters is not a serious problem even now, as will be seen from Table I.

Community Viewing

Apart from the spread of individual receivers, community viewing is also growing in popularity in some countries. The report from Italy given to the conference, for example, referred to the existence of 15,000 sets in isolated rural areas, each with 30-40 viewers, and the so-called 'Tele-Club Movement' in France is the subject of an interesting report (1).

Nine European countries broadcast programmes aimed specifically at farming and rural audiences, namely:

[1]Food and Agriculture Technical Information Service

Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Switzerland and the United Kingdom. Greece, Portugal and Sweden are planning to introduce farm programmes in the near future. In addition, six countries at present have programmes for gardeners.

The hours of transmission for farm programmes average about 30 minutes a week in most countries (Italy enjoys 75 minutes) but in the United Kingdom, for example, where there is more than one channel, each channel has its own farm programme. This substantial output of farm television in the United Kingdom is exceeded at present only by the United States and Canada. In both of these countries television is, of course, very well developed. Canada attaches the fullest importace to its farm programmes, with which it serves five different geographical regions—each with their own special farming problems—by a weekly transmission. Over the next three years, it is planned to increase the number of transmissions until there is actually a programme every day on rural topics—but only half of the programme will deal directly with questions relating to the work on the farm. It is interesting to note that those in charge of agricultural programmes in the Canadian Broadcasting Corporation are all graduates in agricultural science or economics.

Farm TV in the USA

In the United States, farm television dates back to 1948 and now has 100 different farming programmes. Half of these employ agricultural specialists in their production. A weekly 'package', containing information and advisory material specially designed for use by 140 television transmitting stations, is issued by the Television Service of the United States Department of Agriculture, thus achieving a regular and influential means of communication with producers over a wide area of the country.

BBC television cameras filming an operation for the removal of wire from a cow's stomach; the film was being made for the British television programme, 'Farming'.

A television farm programme director using United States Department of Agriculture 'TV Package' visual material.

The principles governing the presentation of farming and rural subjects on television are, of course, essentially similar to those in any other subjects. Nevertheless, marked differences of treatment between one country and another are evident from an examination of tele-recordings of recent programmes in both Europe and North America. The contrast showed up quite clearly when members of the conference at Birmingham were able to attend the transmission of the BBC's regular weekly *Farming*, a programme designed for 'all who live by the land'. This proved to be a very good example of the more searching approach to a subject. For half an hour it dealt exclusively with one subject—the dehorning of cattle. The basis of the programme was a discussion panel, presented in a live studio broadcast and composed of scientists and practical farmers, whose discussions were interspersed with film and other illustrative material.

This almost scholarly approach to the subject contrasted strongly with the magazine type of programme featured on tele-recordings from certain other countries, notably the United States and Canada, which relied for their impact on a short, economical, persuasive presentation. Doubtless, this is derived partly from the convention of dynamic presentation typical of entertainment programmes, partly from the necessity to hold a mixed audience of urban and rural viewers for commercial or

other policy reasons, and also is to some extent a reflection of differences in national temperament.

There is evidence to suggest that the concept of farm television programmes undergoes evolution. In the early 'novelty' phase such programmes as *Looking over the Hedge*, *The Other Man's Farm* and *A Visit to the agricultural Show* satisfy viewers. Later, when the habit of switching on to the programme is established, certain subjects can be gone into more deeply, and will still hold the audience—provided producers do not fall into didactic or solemn attitudes. Also, the outside broadcast which is expensive and difficult tends to give way to studio presentation and the imaginative use of film and still visuals without losing any impact.

Single- or Dual-Purpose ?

Whether a programme should be specifically designed to appeal to the professional interests of the farmers or to mixed viewing audiences is not so clear-cut a question as it might appear. Some farming opinion, for example, urges that the limited time available for farm programmes should be used to increase the goodwill of townspeople towards the industry, by presenting farm life in a way which will enlist their sympathy. This popularisation or general approach to farming is rarely of benefit or even great interest to the farmer-viewer. It is surely more desirable to promote this public relations function—which is a very important one—by contributing agricultural items to general magazine programmes and to devote at least one regular programme specifically to keeping farmers informed about the new developments in their industry and to bringing the view of agricultural research and advisory workers into closer touch with those of the practical farmer—and vice versa.

On the economic side, there are many opportunities for involving urban viewers, as consumers of farm products, by discussing how the link between them—the marketing process—can be operated in a way which is efficient and also equitable to both parties. Consumer education is another subject which may be made interesting as well as beneficial to both town and farming audiences.

Limitation of High Cost

The provision of an educational and advisory organisation for the farming and horticultural industries is characteristic of most countries. Many of them, however, have been slow to develop the use of the various channels of communication with producers. A commentator in a certain European country said recently, '. . . the shocking fact is that we have the finest agricultural research institutes in the world and the most niggardly systems of getting the results of that research down to the farmer'. The advent of television will certainly not, in itself, be the cure-all for this situation. It would indeed be practicable to teach techniques and deliver scientific expositions on farming subjects on television but in most countries, at present, the heavy demands on transmission facilities and the high cost of programme production, to say nothing of the exigencies of the farmers' daily work, severely limit the possibilities in practice.

What television can do *par excellence* is to arouse discussion and interest in current problems. Imaginatively used, in the educational sense, it can act as an appetiser which will prompt viewers to look further for additional information—to advisory workers, to the press, to technical literature, to experimental and demonstration farms and to the radio. The radio is still a most important information and advisory medium for farming, not only in areas of scattered population or those badly served by communications, but elsewhere as well. It will continue to be an informative (and economical) complement to its more spectacular offspring for a long time to come.

The author is indebted to many of the delegates to the Birmingham conference for information concerning the present stage of development of farm television in their countries.

SOME STATISTICS CONCERNING TELEVISION*

Table I

European Countries: Percentage Area Covered (December, 1958)

Television Transmitters now in Service

Austria	20%	Luxembourg	100%
Belgium	90%	Netherlands	100%
Denmark	85%	Portugal	100%
France	90%	Sweden	40%
Germany	80%	Switzerland	70%
Italy	No information	United Kingdom	98%

*With acknowledgment to the FATIS Liaison Officers in Member countries.

Table 2

Approximate Number of Television Receivers in Certain OEEC Countries (December, 1958)

Austria	50,000
Belgium	200,000
Denmark	250,000
France	1,000,000
Germany	1,800,000
Italy	No detailed information. 15,000 receivers in country districts
Luxembourg	2,100
Netherlands	430,000
Portugal	18,000
Sweden	300,000
Switzerland	50,000
United Kingdom	9,000,000

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A general view of the new fertiliser plant at Shell Haven.

SHELL FERTILISER PLAN

A new nitrogen fertiliser plant, with a capacity of 75,000 tons of ammonia a year, has recently been completed at the Shell Haven oil refinery on the Thames estuary. Shell Chemical Company will use 15,000 tons of the ammonia produced each year to manufacture calcium ammonium nitrate ('Nitra-Shell') for sale in the UK. The remaining 60,000 tons of ammonia will be sold to Fisons, Ltd., who have erected a plant a short distance away.

In Holland and in the United States, Shell have some 30 years' experience of producing ammonia and nitrogen fertilisers. In the late nineteen-twenties the Royal Dutch/Shell Group started to investigate the use of natural and refinery gases as a source of hydrogen for use, together with nitrogen from the atmosphere, in the manufacture of ammonia. As at that time there was no Shell source of these gases in Europe, in order to gain experience in the techniques of high pressure synthesis, it was decided to use coke-oven gas, which was readily available, as a source of hydrogen.

The Group therefore set up a company, MEKOG, at Ijmuiden in Holland, to make use of the coke-oven gases available at the plant of the Royal Dutch Blast Furnaces Company. MEKOG started to produce ammonium sulphate in 1929, and, soon afterwards, nitrate of lime.

Eventually, increasing demand outran the supply of coke-oven gas, and additional hydrogen was derived from

The Nitra-Shell unit and, to the left, the storage silo.

One of the plant control rooms.

OPENED IN UK

water gas based on coke. With more hydrogen and nitrogen available, a third type of fertiliser was introduced—an ammonium nitrate/chalk blend.

In the USA Shell were the pioneers in producing ammonia from natural gas, and the first plant, at Pittsburg, California, is still the largest west of the Rockies.

Until recently, the nitrogen fertiliser industry in Europe has been almost entirely based on coke as a source of hydrogen; the new plant at Shell Haven, however, employs a gasification process, evolved as a result of Shell Group research, by which hydrogen can be produced from any petroleum fraction. The hydrocarbon selected is burnt in a special burner in an atmosphere of oxygen and steam, the reaction yielding a mixture of hydrogen and carbon monoxide. More hydrogen is obtained by reacting steam with the carbon monoxide over a catalyst. After purification, the hydrogen is mixed with nitrogen (obtained by the fractional distillation of liquid air), compressed, and passed over another catalyst. The ammonia so formed is stored under pressure as a liquid.

Ammonia to be used for fertiliser manufacture is burnt in air in the presence of a catalyst to give oxides of nitrogen; these are absorbed in water to produce nitric acid, which is then neutralised with additional ammonia to give ammonium nitrate. The ammonium nitrate is mixed with specially treated chalk to make 'Nitra-Shell'.*

*'Nitra-Shell' is a Shell trade mark.

A process column.

Adult, pupa and larva of the rice plant skipper, Parnara guttata, *Bremer and Grey*.

Adult and larva of the rice stem borer, Chilo suppressalis, *Walk*.

Pests of paddy rice

Rice is the most widely grown crop in Japan and in that country, Dr. Tsutsui has stated, about 200 known insect species have been associated with it. The distribution of these species varies widely between the colder north and the warmer south-west areas. In the following article the author reviews the ecology and control of the most important insect pests of paddy rice in Japan.

It is of interest that in 1958, of nearly 18 billion yen (£18 million) spent on pesticides in Japan, something like 11 billion yen represented the control of rice pests.

Seed corn maggots, Hylemyia platura *Meig*.

Illustrations by David Pratt from the author's photographs

An adult white-back planthopper, Sogata furcifera, *Horvath.*

An adult rice stink bug, Lagynotomus assimulans

in Japan

by **Dr. K. Tsutsui,** *Ministry of Agriculture and Forestry, Tokai Kinki Agricultural Experiment Station, Japan.*

So far as control of rice pests with insecticides is concerned, the results of research show that for the immediate control of rice stem borer and paddy borer parathion is particularly effective, and this insecticide is widely used. Dieldrin gives the best control of all insecticides tested for rice leaf miner, smaller rice leaf miner and rice stem maggot. The use of endrin in the paddy field is prohibited because it is toxic to fish, but its use for the control of purplish stem borer and other insects attacking dry land rice is noteworthy. For the control of soil insects such as seed corn maggot, mole cricket and dry land rice root aphids, aldrin and heptachlor are widely used.

IRRIGATED RICE

Rice Stem Borer (*Chilo suppressalis* Walk.)

The physiology, ecology, forecasting of occurrence and prevention of this pest have been studied for many years since it is the most important pest of irrigated rice throughout Japan.

Ecology and damage. Overwintering larvae pupate in rice-stubbles or straw, and the adult moths emerge from the end of May until the end of June. They lay eggs on the leaves of late-seeded rice seedlings in the nurseries, or on recent transplants, during mid and late June. The newly hatched larvae bore into the stems which subsequently wither, delaying or destroying growth and considerably reducing the grain yield. Pupation follows within the rice stems from the end of July until the beginning of August, and the second generation adult moths emerge in great numbers at the end of August. These moths lay their eggs generally on the lower leaf-sheaths and the hatching larvae eat their way into the stems. Most serious damage occurs at this time resulting in incomplete or totally damaged heads which seriously decreases grain yield.

Control. Parathion, EPN and BHC will prevent the attack of first and second generation stem borers. Endrin is as effective as parathion but is not allowed in field use. The application of aldrin emulsions is being studied as first generation larvae control has been as effective as with parathion dust.

Paddy Borer (*Schoenobius incertulas* Walk.)

Irrigated and dry land rice throughout the southern warm areas are affected by this insect. The increased early plant-

ing of seedlings to avoid later typhoon damage has appreciably increased paddy borer infestations.

Ecology and damage. Pupation of overwintering larvae occurs in stubbles at the end of April and the first generation adult moths emerge from mid May to mid June, laying their eggs on the nursery bed seedlings. Second generation adult moths emerge from mid July to early August, laying their eggs on the transplanted rice leaf tips. The larvae damage the plants in a similar manner to the first generation rice stem borer larvae.

Third generation adult moths emerge from the end of August until late September laying their eggs on the leaves. The newly hatched larvae then move over the leaf and leaf-sheath, attacking the best of the plant heads which become white and bear no grain. These so-called 'white-heads' can be observed in groups of 20 or 30 around the place where one egg cluster was earlier deposited.

Control. Parathion and EPN are generally used at heading time on the appearance of third generation larvae.

Planthoppers and Leafhoppers (small brown planthopper [*Delphacodes striatella* Fallen]; white-back planthopper [*Sogota furcifera* Horvath]; brown planthopper [*Nilaparvata lugens* Stall]; green rice leafhopper [*Nephotettix bipunctatus cincticeps* Uhler]; zig-zag stripe leafhopper [*Deltocephalus dorsalis* Motschulsky]).

Despite lengthy and careful research the hibernation of the brown and white-back planthoppers has not been clarified.

Ecology and damage. The small brown planthoppers emerge five times a year, the larvae overwintering on weeds and the adults later appearing in May and June in seedling nursery beds and paddy fields. These planthoppers cause little damage, though they are important as hosts for stripe and black stripe stunt virus diseases.

Four or five generations of white-back planthopper adults are generally found with a high population in Kyushu from mid June until early July, though the August emergence is more numerous and causes most plant damage.

The sap from ripening plants is sucked by large numbers of brown planthoppers during September and October and an epidemic of this insect is most injurious and most feared.

The green rice leafhopper larvae hibernate in weeds and the adults first emerge in May. Five generations are found attacking nursery beds and early transplants but despite their numbers little damage occurs and their importance is as virus carriers. However, during the plant heading period in August and September high populations often cause great damage to the immature heads by sucking the sap.

The zig-zag leafhopper causes little damage itself, but is important as a virus carrier.

Control. BHC dust is applied for planthoppers, whereas for leafhoppers DDT and parathion emulsions are more effective.

Purplish Stem Borer (*Sesamia inferens* Walk.)

The purplish stem borer is less important in irrigated rice culture, though serious damage may occur on dry land rice, foxtail millet, corn, wheat and barley.

Ecology and damage. First generation adult moths emerge at the end of May following pupation of the overwintering stubble-inhabiting larvae. The eggs are laid on corn and millet and the hatching larvae eat into the stems causing withering. Second generation adult moths emerge from mid July until early August laying their eggs on irrigated or upland rice, and the hatching larvae cause similar but more serious damage as with the earlier brood. Third generation adult moths emerge in early September, lay their eggs, and the hatched larvae eat into the ripening rice heads, causing damage somewhat similar to that of second generation rice stem borer larvae.

Control. Generally, control measures are not carried out, though the application of an endrin emulsion is very effective in the early period of damage, to protect the dry land crops.

Rice Plant Skipper (*Parnara guttata* Bremer and Grey)

Voracious eating of paddy rice leaves and the daytime hiding of the larvae in nests made by binding the paddy leaves together are the characteristics of the skippers.

Ecology and damage. The overwintering larvae hibernate in graminaceous weeds or bumbucaceous plants and after pupation the first generation adult skippers emerge from early to mid June. The most serious damage occurs with second generation larvae resulting from the egg-laying of the adults emerging from mid July to mid August. The third generation adult skippers emerge from early to mid September.

Control. In the early period of moth emergence a DDT application is very effective.

Armyworm (*Cirphis unipuncta* Haworth)

Irregular and sudden infestations may appear during the June-July rainy season on inundated paddies, stripping the leaves of every plant. The headed rice may also be damaged by armyworm attack during the autumn typhoon season. Other plants liable to attack are dry land rice, wheat, barley, foxtail millet, barnyard millet, Chinese cabbage, sweet and white potatoes.

Ecology and damage. The period of adult moth emergence is very irregular, and not yet clarified, and hibernation occurs in the larval or pupal condition. There appear to be four generations per annum, and when the infestation is serious the leaves and stems are consumed.

Control. Endrin emulsion is remarkably effective.

Rice Green Caterpillar (*Naranga aenescens* Moore)
Rice Leaf Roller (*Susumia extigua* Butler)
Grass Leaf Roller (*Cnaphalocrosis medinalis* Guénée)

These insects are found throughout the paddy areas feeding on the leaves. Rice green caterpillar is controlled by the application of dieldrin, DDT or aldrin emulsions, whereas the leaf rollers are controlled with DDT and BHC.

Rice Leaf Miner (*Agromyza oryzae* Munakata)

This is the most important injurious insect on irrigated

rice in the colder districts of Honshu and Hokkaido.

Ecology and damage. First and second generation adults appear from hibernated pupae from mid May to mid June, laying eggs on the inside of the plant leaves. The larvae damage the leaves by mining the mesophyll tissues beneath the leaf epidermis; the attacked portions turn white, later withering and retarding plant growth. The damage is enhanced by cold weather.

Control. The application of a dieldrin emulsion or dust at the time of oviposition is effective.

Smaller Rice Leaf Miner (*Hydrellia griseola* Fallen)

Distribution is widespread in Japan, particularly in the colder districts, though under low temperature conditions early planted rice in the warmer areas is greatly damaged.

Ecology and damage. Eggs are laid between 20th and 30th April on the nursery seedlings or transplants, the larvae mining the leaves in a manner similar to that of the rice leaf miner, though the mining occurs in vertical lines. Damage is particularly severe on new transplants in early planted irrigated rice and the entire crop may have a withered appearance.

Control. The application of a dieldrin emulsion or dust at the time of oviposition is effective.

Rice Stem Maggot (*Chlorops oryzae* Matsumura)

Heavy damage occurs in the colder districts, but some warm areas may also be affected.

Ecology and damage. Two generations per year occur in the northern areas and three generations in other districts. The immature larvae hibernate in graminaceous weeds, pupate in the spring, and first generation adult flies emerge in June. Eggs are laid on the leaves and the hatched larvae bore into the stems, consuming the young growing heads.

The second generation larvae do not infest the rice plants in the northern colder districts but return to their weed host plants. Whereas in the warmer districts first generation larvae scar the rice leaves during June and July, the second generation larvae consume the immature heads and the third generation larvae migrate to the weed host plants.

Control. One or two applications of dieldrin at the time of oviposition have been most effective.

Rice Leaf Beetle (*Lema oryzae* Kuwayama)

This is an important injurious insect in the cold districts and the distribution pattern is similar to that of the rice leaf miner.

Ecology and damage. Infestations are easily controlled by the application of dieldrin or BHC at oviposition or egg-hatching.

Stink Bugs (black rice bug [*Scotinophora lurida* Burmeister] rice stink bug [*Lagynotomus assimulans* Dist]; rice bug [*Leptocorisa varicornis* Fab.]).

The black rice bug larvae and adults occur throughout the rice plant growing period, sucking the sap, and they are considered to be as important as the planthoppers.

The rice stink bug and rice bug attack both irrigated and dry land rice at the time of heading.

Ecology and damage. Adults hibernate in nearby weeds or bushes and one generation only occurs per annum.

The black rice bugs emerge as soon as transplanting occurs, and remain until October; attacked plants wither, giving a brown and stunted appearance. A severe attack on the immature heads will greatly reduce the grain harvest.

The rice stink bug and the rice bug swarm to the irrigated and dry land rice as adults, at the time of heading of early planted varieties, sucking the sap from the newly formed heads. Following severe infestation the harvested grain smells and tastes bad.

Control. Endrin and BHC are most widely used.

DRY LAND RICE

The main injurious insects of dry land rice most generally found are paddy borer, purplish stem borer, armyworm and rice bugs. Larvae of the seed corn maggot, *Hylemyia platura* Meigen, consuming newly sown seeds, and the mole cricket, *Gryllotalpa africana* Palisot de Beauvois, attacking seedlings, and also the roots of established plants, are two typical soil inhabiting insects. The dry land rice root aphids such as the apple grain aphid, *Rhophalosiphum prunifoliae* Fitch, the ribes root aphid, *Tetraneura ulmi* Linné, and the Japanese dogwood aphid, *Anoecia corni* Fab, swarm over the roots of young seedlings, retarding the growth. Excellent control is obtained by the application of aldrin or heptachlor dust mixed into the soil.

Distribution of the main injurious insects of rice in Japan

Part of Rice Infested	*South Western Warm Districts*	*Cold Districts*
Leaf		Rice leaf miner
		Smaller rice leaf miner
		Rice leaf beetle
	Rice-plant skipper	
		Rice green caterpillar
	Rice leaf roller	
	Grass leaf roller	
	Armyworm	
Stem	Rice stem borer	Rice stem borer
	Paddy borer	
	Purplish stem borer	
	Green rice leafhopper	Green rice leafhopper
	White-back planthopper	White-back planthopper
	Brown planthopper	
	Black rice bug	
	Small brown planthopper	
	Zig-zag striped planthopper	
Head	Rice stem maggot	Rice stem maggot
	Green rice leafhopper	Green rice leafhopper
	Rice stink-bug	
	Rice bug	
Root	Seed corn maggot	
	Mole cricket	
	Apple grain aphid	
	Ribes root aphid	
	Japanese dogwood aphid	

Growing Rice in India

by **D. M. Balsaver,** *Burmah-Shell Oil Storage and Distributing Company of India.*

Rice is the principal food for half the population of the world. Grown mainly in Asian countries, a third of the world's rice area is in the Indian Union, which produces 23 million tons annually from a crop area of 75 million acres. It is the most extensively cultivated crop in India, and is grown under very wide ranges of rainfall and altitude, and at varying distances from the coast. In the following article the author gives a general picture of rice growing conditions in India today.

Cultivation of rice in India dates back to periods earlier than 3000 B.C. and over this long period of cultivation the plant has adapted itself to varying conditions, so that today in India there are about 4,000 distinct types of rice differing in essential characteristics. In West Bengal and Assam can be found varieties growing in 15-20 ft. of water, while in parts of Bombay State are grown varieties that thrive as a rainfed crop on only 25 in. of rain. Some varieties are grown on the slopes of the Himalayas at an altitude of 5,000 ft. and there are varieties that can be grown, with the protection of embankments, even below sea level, as in parts of Kerala.

One of the important characteristics of the rice crop is the fact that it has a very wide range of seasons. Due to the existence of a large number of varieties adapted to particular seasons, and having varying periods of maturity, it is not unusual to see the rice crop in all stages of growth at the same time, in the same neighbourhood. This means that the Indian cultivator, if he selects his varieties with care, can manage a fairly large area with a single pair of bullocks.

Broadly speaking, however, there are two main seasons —the rainy season, or main crop which is sown approximately about June or July, to coincide with the south-west

Puddling a paddy field.

monsoon, and is harvested in November or December; and the hot weather crop which is sown about December or January and harvested in May or June.

For the main or rainy season crop long duration varieties requiring 150-190 days to mature are used. This crop usually gives a high yield and is the most important crop in the country. Early maturing varieties requiring only 75-100 days are used for the hot weather crop.

Soils and Water Requirements

There is hardly any type of soil on which rice cannot be grown; it is grown on soils only a few inches deep underlaid by rocks, as well as on soils so fine and deep that ploughing with bullocks becomes a dangerous operation, as they sink too deep. It is grown on light sandy soils, on solis with a high humus content and on soils with a fairly high degree of alkalinity—conditions under which no other crop can be grown economically. But the best type of soil for rice is a clay loam such as is found in river deltas.

Rice is a semi-aquatic plant and is best grown where there is a plentiful supply of water at the right time. The bulk of the rice in the country is grown under rain-fed conditions and therefore the success or the failure of the crop depends very much on the rainfall. Owing to the vagaries of the monsoon, the Government has realised the need to provide irrigation facilities and today about 20 per cent of the rice area has irrigation facilities.

India has the largest mileage of irrigation channels in the world, and this is being extended yearly with the completion of extensive irrigation and hydro-electric projects. In the north, the rivers are fed from the melting snows of the Himalayas and irrigation facilities from these rivers are provided by the construction of dams. In the south, in addition to canal irrigation provided by constructing dams, tank irrigation, for which big reservoirs with a large catchment area are employed for the storage of rain water, is popular. Tube wells are also being sunk in all parts of the country to augment irrigation facilities.

The cultivation of rice requires that irrigation water should stand evenly in the field throughout the growing period of the crop and be capable of flowing out in a

gentle flow, the level of the water in the field being at the same time maintained. This imposes a restriction on the size of the fields and is one of the reasons for the small plots one often comes across.

Cultivation

Depending upon whether the crop is grown with the help of rain only or with irrigation, the cultivation of rice is divided into two categories, 'dry' cultivation and 'wet' cultivation, or cultivation in puddle.

In the dry method of cultivation the fields are tilled with a heavy bladed harrow as soon as the early pre-monsoon showers appear; these early showers help to produce a good tilth. Seed paddy is sown through a seed-drill and is covered by a light harrowing. Seeds germinate and seedlings are well established by the time heavy rains flood the fields, and from then onwards the plants grow under the usual flooded conditions.

Wet cultivation differs from dry cultivation in that the preparation of the field starts when the soil is not only fully soaked but has at least two inches of standing water on it. Repeated ploughing and cross ploughing (called 'puddling') under such conditions results in a soft top soil with a fairly impervious sub-soil. The seeds may be sprouted first and then sown, or raw untreated seeds may be sown direct into the puddled fields, or the seedlings may be raised separately in a nursery and then transplanted. Transplanting of seedlings is the more common practice, and among its several advantages the most important is that it enables a more effective control of weeds to be obtained.

Wet cultivation results in a higher crop yield, which is believed to be due to certain bacterial changes taking place as a result of puddling. The dry method makes possible an extensive use of bullock-drawn implements for work which in the wet system is largely done by human labour.

Irrigation. Control of water forms an important operation in the cultivation of rice and, as already mentioned, the aim is to allow a gentle flow of water while maintaining the level in the field. A week or so before harvesting, the field is drained off completely.

Manuring. Rice responds well to manuring and Indian soils being generally deficient in organic matter and nitrogen, substantial increases in yields have been obtained with the use of green manures and inorganic fertilisers. Green manure crops such as *Sesbania speciosa* and sunhemp are grown *in situ* and incorporated with the soil at the time of puddling. Superphosphate at 100-150lb. per acre is applied to the green manure crop or mixed with the soil at the time of puddling.

Ammonium sulphate is the most commonly used nitrogenous fertiliser and is applied at the rate of 150-200lb per acre. Half the recommended dose is applied at the time of transplanting and the rest is applied as a top dressing after the first or the second weeding. As sulphate of ammonia is soluble in water, sub-surface application has been found to give better results than surface broadcasting.

Weeding. Although neglected in the past, weeding is an important operation, especially in the dry cultivation of rice. It is normally done by hand although in areas where seeds are drilled or seedlings are transplanted in straight lines, rotary hoes are becoming popular.

Harvesting. Harvesting is begun after the grain has passed the dough stage but before it is quite ripe, allowing the completion of ripening to take place in the stack. If harvesting is delayed, there is a considerable loss of grain from shedding at harvest.

After harvesting the crop is allowed to dry in the fields for about three days before being taken to the threshing yard. Threshing is carried out by beating the earheads on a stone or an inclined plank. By this method all the grain is not recovered and what is left over is removed by a second threshing, where the earheads are trampled over by cattle. The Japanese pedal-thresher has now been introduced by the Government and is proving popular.

Pests and Diseases

The most important insect pest of rice is the stem borer (*Schoenobius incertulas*) which causes up to 80 per cent loss in production. The continuity and distribution of this pest is facilitated by the vast contiguous areas under rice production and the overlapping rice seasons. Spraying with modern insecticides has helped to give a large measure of control, but the purchasing power of cultivators is extremely limited and even with Government assistance progress is slow. Endrin, BHC and parathion are the commonly used insecticides. Although dusting is more popular than spraying, farmers are now beginning to recognise the effectiveness of the latter method.

Other important insect pests include Gundhi bug, *Leptocorisa* sp., rice hispa, *Hispa amigera*, and army worm or swarming caterpillar, *Spodoptera mauritia*. Whilst aerial spraying is resorted to in times of epidemic and under Government legislation, the use of aircraft at other times is virtually impossible to organise since the vast tracts under cultivation are owned or rented by individual cultivators, each of whom has a holding of sometimes less than an acre. It is to be hoped that the Government's emphasis on co-operative farming may lead to an increased use of aircraft in the future.

Diseases, amongst which those caused by fungi are the most important, cause approximately 10-15 per cent loss in production, but in years of great epidemics this may well rise in affected areas to 50-90 per cent of the crop.

The most important disease is 'blast', caused by *Piricularia oryzae*. The disease appears on the leaves as spindle-shaped spots and in the later stages affects the bases of earheads. The affected earheads have very poor grain setting, and yield is considerably reduced. Control measures include the growing of resistant varieties, treatment of seeds with copper or organo-mercurial fungicides and spraying with copper fungicide. Also important is stem and foot rot, caused by the fungus, *Helminthosporium*.

Stored rice is very susceptible to attack by storage pests,

Transplanting rice seedlings.

the most common among them being the rice weevil, *Calandra oryzae*, and the rice moth, *Corcyra cephalonica*. Common methods of protecting rice in storage are mixing it with turmeric powder, or storing it in an earthenware or wooden bin filled to the brim and covered with a one-inch layer of sand. Modern fumigants and insecticides are slowly being adopted by large Government warehouses.

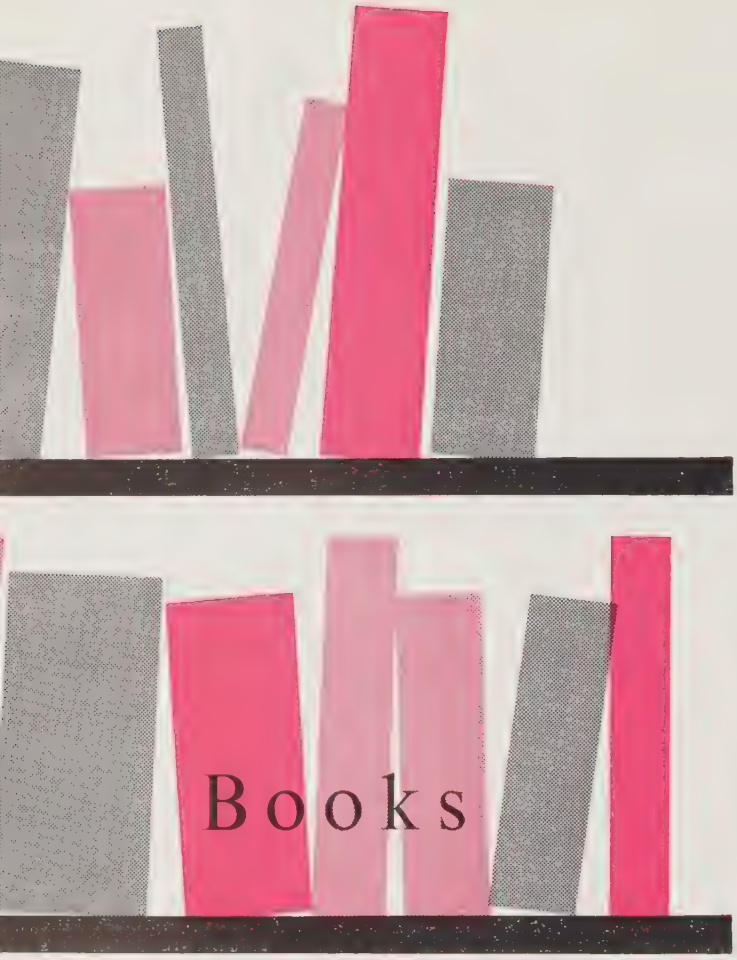
Rice Research

In a country where 30 per cent of the annual cultivated area is occupied by rice, and which has the largest acreage under rice in the world, prominence is naturally given to rice research. Under the Indian Council of Agricultural Research there are 76 research stations spread throughout the country, conducting work on various aspects of rice research. Among the problems tackled are breeding of high yielding varieties, manurial requirements of different varieties under different soils, breeding of disease-resistant and drought-resistant varieties and control of pests and diseases.

Already 455 superior strains of rice, giving on average 10-20 per cent higher yield, have been evolved.

In spite, however, of research facilities and 5,000 years of experience in cultivating the crop, India has perhaps the lowest yield per acre in the world. Some of the reasons for this anomaly may be found outside agricultural practice. It has been said that the problems in agriculture are social, political and economical before they become technical. With years of a very low standard of living, farmers have reached what may be called an 'under-development equilibrium' where a slight increase in agricultural production merely results in increased consumption with very little net gain in the economical position of the farmer.

Realising the need for a rapid increase in agricultural production the Government has launched the bold and imaginative Community Development Programme which aims at tackling the agricultural problem simultaneously from various angles. Agricultural production in community development areas has already shown an increase of 50 per cent and it is hoped that, with the extension of community development projects to cover the entire country, rice production will increase sufficiently to meet the country's requirements.



Grass Productivity. ANDRÉ VOISIN (English translation by C. T. M. Herriot). Crosby Lockwood, London. 50s.

M. André Voisin has done a service in presenting first a German and now an English translation of his book, the original of which is in French, and perhaps an even greater service in the emphasis he lays on the relationship between grass and the grazing animal. It is high time that crop and animal should be regarded as part of an environment in which both live interdependently.

The study of pasture growth in relation to treatment can properly be an end in itself, but only where comparative yield studies are sought after. Similarly, the comparative study of animal behaviour within different treatments provides an important and profitable field of inquiry. The integration of these problems of husbandry, however, often proves to be more difficult, but even so they are most essential if the findings of plant and animal research workers are to be fully exploited to provide a practical technique for use on the livestock farm. Many such techniques have, of course, found their way into general practice. M. Voisin presents a new technique which he has found to be valuable on his own farm in the Department of Seine-Inferieure near Dieppe.

Grassland provides the basic feed for the ruminant animal, but as we intensify our agriculture it becomes ever more important to produce the maximum possible from grass alone, because grass is a cheap source of food and is easy to produce under normal conditions of climate in Western Europe. We have extensive knowledge concerning the increase of output from British grasslands, but much less is known by the farmer as how best to use his grass during summer, while there are many unsolved problems concerning the conservation of excess summer production to cater adequately for the long winter.

A major problem connected with grass production is the seasonal nature of its growth, unless special arrangements are made to cater for fluctuating yields. M. Voisin describes his own techniques which he has found successful on his own farm. Briefly, he divides the dairy herd into groups, offering the choicest new growth to the high yielding group, and using the one or more remaining groups as followers. This principle has, of course, been much used in the past and especially following upon the work at Hohenheim in Germany after 1920.

M. Voisin also advocates 'rational' grazing, designed to compensate in part for seasonal growth fluctuations. He does this by varying the number of paddocks in the grazing rotation at different times during the summer, thereby shortening or lengthening the period of rest in conformity with the rate of production. He also compensates by other means, e.g., by purposeful application of nitrogen fertiliser, emphasising always that flexibility in management as well as flexibility in grass production are keystones in the economic running of a dairy herd at pasture.

M. Voisin defines four laws of rational grazing which may be summarised as follows:

1. To be highly productive, pastures must be rested between successive grazings;
2. Paddock grazing should be carried out quickly, so that none of the plants is eaten twice during a given grazing period;
3. High-yielding animals are presumed to have the greater need of food, and these therefore should have first choice of grazing;
4. Deep milking cows should not be grazed on one paddock for longer than three days—one day per grazing paddock is the ideal, according to M. Voisin.

The book is well presented and the translation is on the whole good. M. Voisin's theme is well worth study and cogitation. WILLIAM DAVIES.

Micro-Organisms in the Soil. ALAN BURGES. Hutchinson's University Library, London. 10s. 6d.

This is a small book of 190 pages, which describes the advances that have been made, during the last 10 years, in soil microbiology. It is very readable, and should be read by all students of biology, for whom, I think, it is primarily intended. They will find it useful in broadening their ideas of biology, which is still sometimes taught as a purely laboratory subject. That is not to say that other readers will not profit from this book; it is a good and well-written introduction to a fascinating subject.

Professor Burges treats soil microbiology primarily as a branch of ecology, which is probably the approach to the subject that is most likely to discover facts of fundamental importance. Other writers on the subject have dealt with it as a branch of agriculture, which ultimately it doubtless is, but all the same this is an approach which can lead to some mental confusion. Experiments in microbiology performed with soil often give inexplicable results, because the fundamental knowledge needed to interpret them is still lacking. In spite of this, studies of soil micro-organisms are, in essence, studies on the causes of soil fertility, and are therefore of great ultimate importance.

Micro-Organisms in the Soil begins with a chapter on the soil and its structure, which gives a short but clear account of

the physical and chemical properties of soils of different types, including Russian work on pedology. The micro-organisms themselves are dealt with in eight following chapters. It is always a little difficult to decide just what is a micro-organism; in this book the nematode worms are included but the small mites and insects are not; and the basidiomycetes are included as well as the microfungi. This, I am sure, is quite realistic, for basidiomycete mycelium is obviously very widespread in soils, to judge by the numbers of mushrooms and toadstools which appear. But, as the author points out, existing methods of isolating fungi from soil give practically no information on the basidiomycetes.

Most of the examples in this book, and the experiments described, deal with the fungi. The reason for this seems to be not only that the author is a mycologist, but rather that more advances have been made in recent years in knowledge of the microfungi than of other microbial groups in soil. This is probably because research workers in other disciplines—plant pathology and industrial microbiology for example—are interested in the growth of fungi. But there are of course still great gaps in our knowledge. This applies even more to the soil bacteria, which are more difficult to identify than the fungi.

It is evident that the existing methods of isolation give us only a fraction of the bacterial population of a soil, and, as the properties of those species which have not been isolated are mostly unknown, it is equally unknown whether the bacterial species which have been cultivated from different soils are in fact the species responsible for various soil processes. Even greater doubt surrounds the function of algae in soil, as the book points out. Actinomycetes in soil have been intensively studied, but from one aspect only—namely, as producers of antibiotics.

The book is not, of course, complete in itself; it does not pretend to be a textbook, but it is an introduction to the subject for the intelligent reader. It has no illustrations of the organisms it describes. The descriptions of techniques are not given in detail, so that the book could not be used as a practical handbook; but this point is covered by a very well chosen list of references. It is obviously the author's intention that his readers shall go on to read the references he gives, not only as a source of techniques, but also to gain more knowledge of an interesting and useful subject.

That the book points out where the gaps in the existing knowledge of soil microbiology lie, will, I hope, stimulate research in this important, but neglected, field.

JANE MEIKLEJOHN.

The Conservation of Natural Resources. RICHARD C. HAW. Faber & Faber, London. 30s.

Perhaps the title leads us to expect more weight than we get. After all, it might grace a tome or a series of volumes on this immense subject; but the text runs to less than 250 pages and the surprising thing is that Mr. Haw has touched upon so much in so short a space. Solar energy, food algae, fish farming, composting urban wastes, producer gas, dam building—these are but a few of the many aspects covered in a readable and interesting way. Yet 'covered' is hardly the word, because mostly we get only a superficial glimpse of subject after subject. With appetites whetted we shall turn to other more specialised walks to find the meat; and, unfortunately, the bibliography will not help us much.

But this is not entirely fair, because in five of the 11 chapters we find the substance of the book. Here we are very competently introduced to field engineering for soil and water conservation in southern and eastern Africa, methods of land reclamation, farm road construction, dam building, terracing—these and more besides are described in a useful and practical manner. An appendix contains a list of plants used for conservation purposes and the illustrations, which are of good standard, adequately supplement the text.

The book is well worth its price to any farmer in eastern and southern Africa who intends to look to the conservation of his farming resources. We find much of interest about land use planning. The neat illustration of land capability classification is both clever and clear; but notably lacking from this volume —and, indeed, from most of the literature on the subject—is any mention of costs and labour requirements, either in the practical business of implementing a farm plan or in subsidiary activities described in the text, such as compost making.

The author engagingly invites the student of world agriculture and human affairs to think, and to think conservation-wise in particular. Wherein, then, lie the book's shortcomings? It is not a volume that the impecunious student will select as a 'must' for his shelves. He will not want to go back to it time after time unless he happens to become a farmer with gulleys to control and terraces to construct. The chapters dealing with parts of the subject other than conservation engineering are too general (and readable) to be useful for detailed reference; but they seem to serve two purposes, to set the broad backdrop of natural resources into the Rhodesian farming scene and to convey the author's personal philosophy of conservation.

One does not for a moment doubt the author's sincerity, but it is apt to be embarrassing when reading a technological text to come across another man's concept of what in this world is natural and God-meant.

There are one or two things that picked upon and taken out of context could become intriguing red herrings. For instance, 'it is good for the land to be under private ownership': it is interesting to speculate how many of the custodians of the world's natural resources would wish to agree. J. E. MAYNE.

Recognition of Diseases and Pests of Farm Crops. E. GRAM, P. BOVIEN and CHR. STAPEL. Heffer, Cambridge. 35s.

This unusual book was originally published in Danish by the Danish Agricultural Information and Advisory Aids Service and the edition published by W. Heffer has a condensed text in Danish, English and French. The book aims simply to help farmers and others to diagnose the causes of troubles in their crops, and gives no advice on methods of controlling the pests and diseases. Indeed, the text is only a few words, the equivalent of captions, describing the conditions illustrated in the more than 700 figures contained in the 112 colour plates.

The figures are all reproductions of water-colour paintings by Ingeborg Frederiksen and Ellen Olsen, and excellent they are. Not only are they accurate with the specific diagnostic features clearly shown, but they are works of art, some of surprising beauty. Many people other than plant pathologists will derive considerable pleasure from simply turning over the pages and looking at the pictures. However, identifying the pests and diseases is the purpose of the book and the value of the paintings for this purpose is fully shown by the fact that Figure C of Plate 1, described as 'Red Oats, cause unknown', can be unhesitatingly diagnosed as oats infected with cereal yellow dwarf virus. The standard of reproduction is as high as the quality of the paintings, which is saying a good deal.

The pests and diseases are arranged in eight groups, starting

with cereals, and then grasses, legumes, beet, crucifers, potato, carrots and ending with flax. The book was, of course, meant primarily for north-west Europe, but these crops (and their pests and diseases) occur in many other parts of the world, and the book should prove valuable, both for its stated purpose and for teaching plant pathology, the world over. There are indices in Danish, English and French, and one for Latin names of plants and animals. Carefully thought out and beautifully executed, this is a book to be highly commended and strongly recommended. F. C. Bawden.

An Introduction to Tropical Agriculture. Sir Harold Tempany and D. H. Grist. Longmans, Green & Co., London, New York and Toronto. 40s.

This book in the publisher's tropical agriculture series numbers 324 pages and is divided into three parts: The Tropical Background, Agricultural Practice in the Tropics, and Economic Considerations. It is illustrated by a number of excellent photographs including several in colour.

The book forms a very useful introduction to tropical agriculture, though the standard is considerably more elementary than one would expect to find associated with two such eminent names as those of the authors. It is possible, however, that the original intention of the authors was to provide a basis not so much for the graduate specialist in tropical agriculture as for the training of the ever increasing numbers of native students of agriculture in the tropics who are being trained for intermediate rather than specialist positions in their profession. This would explain why some of the rather wide generalisations which are drawn in places are often without citation of specific examples.

The more senior student will be disappointed at the lack of any reference to work on evapotranspiration, the literature on which, in the form of research papers, has been accumulating steadily over the last decade and has revolutionised our thinking on the subject of moisture relationship. No references are to be found in the fairly extensive bibliography to the work of Penman, Pereira or Thornthwait. The subject is difficult, it is true, but that hardly seems an excuse for its omission in a book of this kind.

One or two small errors are to be noted; for example, insecticides are sprayed, not dusted, both from the air and from the ground for the control of jassids on cotton in the Sudan (page 200). References to synthetic insecticides, including systemic insecticides, are fairly obviously some years out of date (page 195-196).

Whilst the book will no doubt form an excellent junior text-book for the general student of tropical agriculture it should be emphasised that this is no work of reference such as would be considered a 'must' on the specialist's book-shelf.

K. Wilson-Jones.

Plant Growth Substances (second edition). L. J. Audus. Plant Science Monographs No. 1. Leonard Hill, London. 65s.

Few branches of research are developing as rapidly as that concerned with plant growth substances and the volume of literature which has been published in this field since the first edition of this book appeared in 1953 is very extensive. It has been by no means an easy task therefore to bring the story up to date. The author has not only done this but in doing so has produced the best and most comprehensive text book yet published on this important subject. Throughout the volume fundamental aspects receive careful treatment, research developments are fairly reviewed and proper attention is given to the contributions of European as well as American workers in this field.

As in the first edition, emphasis is given to the physiological principles underlying the action of growth substances, a knowledge of which is so essential to all who are interested in these materials. This emphasis, however, is rightly carried further in this second edition by the inclusion of a new chapter on the mechanism of auxin action which is dealt with in terms of basic physiology. At the same time, important developments on chemical aspects, including structure/activity relationships, mode of action and so on, have necessitated a considerable expansion of the chapter on chemistry of the auxins.

Other changes in the book are shown in the more detailed treatment given to flowering control and chemical control of sexual processes in lower plants and to non-auxin type growth substances. The chapter on abscission has also been expanded.

In this revised edition the author has continued to have the non-scientific layman as well as the scientist in mind. Whilst it is true there is something to be found in the book for all classes of reader, 'Audus' is becoming more and more a standard reference book for students and others who are directly interested in this field. As in the first edition, the physiological approach adopted is useful and stimulating to the chemist, and the physiologist, likewise, will find the chemical treatment satisfying. An account is given of progress made in a number of important lines of research which still require much attention. Thus, it remains to be shown whether a flowering hormone actually exists; there is also much to be discovered about naturally occurring hormones and growth inhibitors in plants.

The volume is very well written and produced and it includes a number of excellent diagrams and photographs. Many references to original work are given in the bibliography and there are appendices relating to the use of specific compounds for the rooting of cuttings, the setting of fruit, weed control, preventing the preharvest drop of apples and for inducing abscission.

This excellent volume should be on the shelf of all those botanists, chemists and agriculturalists who want to know more about the growth of plants. R. L. Wain.

Biological Laboratory Data. L. J. Hale. Methuen, London. 15s.

Within the limits set by the size of a Methuen Monograph, Dr. Hale has succeeded in bringing together a considerable amount of information of use to the experimental biologist.

The selection in the Mathematical Data section is particularly good and would seem to provide the average research biologist with all the mathematical and statistical tables as well as basic formulae he is likely to require.

With regard to the sections dealing more specifically with biological laboratory data, i.e., those on culture media and histological data, the emphasis is more on data of use in animal biology and the plant biologist may feel somewhat neglected. One would like to suggest for inclusion in a future edition information on such topics as culture media for fungi, bacteria, etc., staining techniques for bacteria, and dyes for the differential staining of fungi in plant tissues.

There is no doubt that this is a most useful booklet, but why has it to follow the practice, usual with books of this kind, of omitting the lb./sq. in.—atmospheres conversion from its otherwise very informative section on inter-relation of units?

H. F. Dammers.

Green into Gold

As long as springtime melts the snows of the Rocky Mountains, the desert will grow green a thousand miles away. From the Colorado River, through the All-American Canal, sweet, silt-free waters now flow abundantly to what was once a heat-crazed, hostile wilderness where only cactus and sagebrush grew and gold-hungry men died for the want of a drink. Today, that same Californian desert gives richly. And the colour of its 20th century gold is the green of a lettuce leaf.

In the Imperial and Salinas Valleys of California and the Salt River Valley of neighbouring Arizona are grown both the best lettuce in the country and the biggest commercial volume. Farming is on a very large scale, over some 180,000 acres, and nothing is left to chance. Unfortunately the constant heat, together with ample moisture from irrigation, provides ideal conditions for insect pests —particularly aphids and the cabbage looper, *Trichoplusia ni* (Hbn.). Infestation builds up throughout the season, sometimes increasing heavily just before harvest, and when this happens, the marketability of the crop is greatly reduced. Until recently, because of undesirable residues left on the leaves, there was no effective insecticide which could be used at this critical time.

With Phosdrin, Shell's new systemic insecticide, however, the problem is being solved and lettuce-growers are enthusiastic about the results already obtained. Phosdrin is both fast-acting and fast-disappearing *and can safely be used within only a few days of harvest.* Its killing power is dramatically swift, and with this important new insecticide Shell offers to growers of many crops a greater hope of unspoilt harvests. Phosdrin, in a modern alchemy, can turn green into gold.

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Phosdrin is the sixth in the series of Shell insecticides for world-wide use. A systemic organo-phosphorus insecticide of exceptional power, it has the outstanding advantage that its residues are rapidly dissipated. It is thus the ideal insecticide for close-to-harvest use. If ***you*** *have a pest problem in your area, consult your Shell Company. Between them, aldrin, endrin, dieldrin, Phosdrin, D-D and Nemagon offer control of virtually every significant pest.*

Trichoplusia ni (Hbn.). *Cabbage looper*

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